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Daar de proefschriften in de reeks van de Faculteit Economie en Bedrijfswetenschappen het persoonlijk werk zijn van hun auteurs, zijn alleen deze laatsten daarvoor verantwoordelijk.

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Chapter 1
General Introduction

1.1 Multinational firms perspective

Multinational firms (MNE) represent the engine of globalization. Their pervasive presence accounts for one third of current world GDP, and 50% of world exports (Cadestin, et al., 2018). MNEs are considered to have a superior performance (Helpman, et al., 2004), and to be the responsible for a dominant share of (technological) knowledge created in the world. For almost half a century, international business scholars have studied the MNE. This prolonged academic effort generated a considerable body of theories and evidence on the subject.

Early research has associated the existence of multinational firms with the possession of certain firm specific advantages initially developed in the home country. In his seminal work, Hymer (1976) suggested that these advantages are transferred across borders by MNEs that exploit them to operate and compete in foreign markets. These home based advantages counterbalance the difficulties arising from operating in unfamiliar business environments and provide the MNE with superior capabilities to outperform local rivals. Around the same period, Buckley and Casson (1976), in their 'internalization theory', used the *transaction cost* argument of imperfect intermediate markets to explain why firms opt for a multinational configuration that allows them to transfer their proprietary assets internally. In the presence of market failures this is seen as the most effective solution to minimize the costs of their international operations. Moreover, although not specified by Hymer, most of these advantages are assumed to consist in intangible assets in the form of superior organizational capabilities, technical expertise and marketing activities that allow firms to offer a differentiated product to the market (Caves, 1971; Rugman, 1981). By internalizing the transfer of these intangible assets, MNEs appropriate returns on investments in these intangibles on a global basis. Another classic theory, the Product Life Cycle of Vernon (1966), suggests that firms decide to open manufacturing facilities in other countries and become MNEs once the home market for their products is mature and trade costs make it convenient to serve other, less developed countries locally.

All these traditional theories share a 'top-down' approach with a hierarchical view on the multinational firm. In this perspective, the headquarter creates and controls firms' specific advantages, which in turn are applied by subsidiaries that function as 'mini-replicas' of their

parent firm in foreign markets. More recent contributions, in contrast, moved beyond the idea that capabilities are developed exclusively in the home country and started to recognize that subsidiaries can be important actors within the MNE. This new stream of studies began to consider the MNE as a 'heterachical' organization composed by a group of semi-autonomous geographically dispersed subsidiaries (Hedlund, 1986). These subsidiaries form an internal organizational network where each node is responsible for a specific value adding activity that is then integrated within the MNE. At the same time, while conducting their operations, subsidiaries are also likely to establish relationships with local partners and to actively engage in the external network formed by the actors present in the local environment (Andersson & Forsgren, 1995, 1996; Andersson & Pahlberg, 1996). This interplay of multiple layers of internal and external interactions has led scholars to conceptualize the MNE as a 'differentiated network' (Ghoshal & Bartlett, 1990; Nohria & Ghoshal, 1997). Studies have empirically examined the potential role of the local system as a source of new ideas and business opportunities for the subsidiary and the MNE. The geographic distribution of knowledge creating activities such as R&D across subsidiaries active in different local environments can stimulate the diversity of knowledge present in the MNE (Phene & Almeida, 2008; Berry, 2014; Kafouros et al., 2012). Nevertheless, to manage these 'multi-hub' R&D organizational structures efficiently requires further efforts and resources devoted to the coordination and promotion of knowledge flows within the MNE internal network. (Criscuolo & Narula 2007; Narula 2014; Lahiri, 2010).

Autonomous subsidiaries that are tightly linked with the local business environment might not share the same objectives of the MNE and thus be less willing to contribute to the MNE's success. Moreover, specialized subsidiaries that developed valuable competences in their location might not be willing to make them available to the rest of the MNE to avoid losing their relevance in the group (Mudambi et al., 2014; Ambos et al., 2010). In this perspective, the MNE risks to become a *federation* where each subsidiary adopt a rent-seeking behavior and compete for more influence and power within the organization (Ambos et al., 2010). Mechanisms that facilitate knowledge exchange such as the creation of social structures and motivational processes (Schleimer & Pedersen, 2014), inter-subsidiary knowledge communities (Tallman & Chacar, 2011) and R&D collaborations (Lahiri, 2010; Singh, 2008) might help MNE to integrate and benefit from the dispersed knowledge available in the group.

However, too much control and integration in the MNE network could still suffocate subsidiary creative initiative through local knowledge sourcing, this can give rise of an

innovation/integration paradigm as defined by Mudambi (20110). In line with that, a recent study of Berry (2018) found foreign subsidiaries that were too embedded in the internal parent firm knowledge network to make more incremental and less radical innovations. Therefore, MNEs must balance subsidiary internal embeddedness within the MNE network and its external embeddedness with the local environment (Meyer, et al. 2011).

This network view of the MNE initiated a gradual shift in the focus of analysis from the 'MNE' to the subsidiary level (Rugman and Verbeke, 2001). Subsidiaries are not simply seen as subordinate units but can take an active role as nodes in the MNE network. MNEs develop capabilities and resources in different geographic locations which must be internally transferred and shared within the organization (Ghoshal and Bartlett, 1990). This interpretation of the MNE is in line with the 'resource based view' of the firm in the strategic management literature (Barney, 1991; Grant, 1996), which looks at firms as unique bundles of resources and capabilities underlying their competitive advantages. Consistent with this view, competitive advantages in one subsidiary of the MNE can be built on capabilities and resources developed in other subsidiary (Ohmae, 1990; McEvily and Zaheer, 1999). Hence, foreign subsidiaries have the potential to become an important strategic resource for the international competiveness of the MNE (Gupta and Govindarajan, 1991; Birkinshaw, 1996; Rugman & Verbeke, 2001).

1.2 Subsidiary perspective

The gross output of foreign subsidiaries grew almost three-fold between 2000 to 2014, from 7 to 20 trillion US dollars. Foreign subsidiaries currently account for approximately one third of total MNEs output and slightly more than 10% of total global output (Cadestin, et al., 2018). Because of the increasing economic and strategic relevance of subsidiaries within the MNE, several studies have started to focus attention on their performance (Andersson et al. 2002; Venaik et al., 2005). Particular attention has been devoted to subsidiary knowledge capabilities and, in general, the ability of subsidiaries to create and diffuse within the organization knowledge that can be exploited in the international markets (Frost, 2001; Almeida, 1996).

To explore the subsidiaries' evolution and the success of their operations it is necessary to apply multiple theoretical perspectives that consider the nature of subsidiaries as embedded in and exposed to the multinational group as well as their local environment. These two dimensions add to the specific capabilities that characterize each subsidiary and contribute to determine the choices and effects of subsidiaries' strategic actions. In line with the model proposed by

Birkinshaw and Hood (1998) on subsidiary initiative and development, subsidiary activities are influenced by factors playing at three different levels: *a)* the MNE group *b)* the local environment and *c)* the subsidiary level.

1.2.1 The MNE factors

The stream of literature looking at the strategies and organizational structure of MNEs assumes subsidiaries' evolution to depend on the strategy chosen by the MNE at the global level (Bartlett & Ghoshal, 1989; Prahalad & Doz, 1987). Subsidiaries are ultimately owned and controlled by parent firms that have established them in the first place with a clear objective that defines their conduct. The choice to set up the subsidiary, the initial resources allocated to their operations and the tasks they are assigned to, reflect the international strategy that parent firms adopt according to the global structure of the industry and the pressures from international competitors (Birkinshaw et al., 1995). In this perspective, the subsidiary is considered as part of the MNE's portfolio of activities in the international markets. In line with the widely accepted global integration-local responsiveness framework (Bartlett & Ghoshal, 1989; Prahalad & Doz, 1987), the strategy chosen by the parent firm simultaneously affects the degree of adaptation of subsidiaries to their local markets as well as the integration of their operations with the rest of the MNE network. Subsidiaries of globally integrated MNEs might focus on specific value adding activities whose function and performance would be inextricably tied to actions taken in the rest of the MNE group. Consequently, also subsidiary's own existence could depend on the strategic international configuration chosen by the parent firm (Benito, 2005), which can vary dynamically depending on developments in the global market.

The MNE is also an important element in the context of subsidiary knowledge creation, as MNEs have the ability to integrate and diffuse the diverse knowledge held by geographically dispersed subsidiaries. The presence of a recognized organizational structure with defined common values and procedures facilitates intra-firm knowledge exchange. Existing studies have highlighted the importance of a developed, multi-channel system of communication between different subsidiaries to increase the flow of knowledge within the MNE (Gupta & Govindarajan, 1991, 2000). In this context, subsidiaries are expected to absorb valuable knowledge through two main channels: 'vertically' from headquarters (Delios and Beamish, 2001; Fang et al 2013; Fang et al, 2007; Fang et al., 2010) and 'horizontally' from sister subsidiaries (Phene & Almeida, 2008). Finally, subsidiaries can use the MNE know-how to gain in efficiency and maintain a competitive advantage in their local market, but they can also

use it as an input to generate new innovation that further expand the knowledge base of the entire MNE group (Frost, 2001). Hence, subsidiaries are expected to access and assimilate know-how from the rest of the MNE network (Almeida & Phene, 2004).

1.2.2 The local factors

The characteristics of a location define its degree of attractiveness to foreign direct investments (e.g. Alcácer & Chung, 2007; Bas & Sierra, 2002; Basile, Castellani, & Zanfei, 2008; Kumar, 2001). Locational advantages in terms of market access, resource availability, costs of production and strategic assets are mentioned by Dunning (1993) in his *eclectic paradigm* as reasons why firms expand their operations overseas. Likewise, alterations of those local factors over time may induce MNEs to reconsider their presence in the host country once the initial location motives fade out, thus increasing the likelihood of closure and divestments (Benito, 1997; Berry, 2013).

Not only does the local environment influences investment and divestment decisions, it also affects the subsidiary throughout its development (Meyer et al., 2011). In this sense, particular attention has been given to the role of the local environment in the innovative process of individual subsidiaries (Frost, 2001). Locations tend to follow a path dependent evolution shaped by a combination of distinctive elements such as infrastructure capacity, institutions, established business networks and innovation systems that are difficult to reproduce elsewhere. As a result, the stock of knowledge accumulated in a location is difficult to diffuse across long geographic distances (Jaffe et al., 1993). Only actors that are physically present in the location can benefit from knowledge spillovers and direct access to the tacit knowledge accumulated in the location. Subsidiaries embedded in the local network are expected to develop capabilities in sectors where the country or region presents a competitive advantage (Cantwell, 1989, 1995; Papanastassiou & Pearce, 1997; Cantwell and Janne, 1999).

In a world where innovation becomes globalized and national innovation systems are in competition with each other (Florida, 1997; Furman et al., 2002), subsidiaries allow MNEs to tap into localized knowledge and expertise from geographically dispersed technological clusters. While R&D activities used to be concentrated in the headquarters (Belderbos et al., 2013), studies have documented that MNEs have started to decentralize their R&D close to center of excellence in order to access cutting edge technologies and remain competitive in the global markets (Cantwell & Jane, 1989; Singh, 2007; Song & Shin, 2008; Iwasa & Odagiri,

2004; Florida, 1997; Berry, 2006, Belderbos, 2003). Subsidiaries source tacit local knowledge by undertaking innovative activities locally (Griffith et al., 2006; Cantwell & Mudambi, 2005), hiring local talents (Lewin et al., 2009; Almeida & Kogut, 1999), collaborating with the indigenous scientific community in joint R&D projects (Song et al., 2011) and by interacting with local costumers and specialized suppliers (Porter, 1990). Prior studies on knowledge flows using patent data have confirmed subsidiary local knowledge sourcing (Almeida, 1996; Singh, 2007). The technological strength of the local environment may stimulate subsidiaries to generate further innovation (Iwasa & Odagiri, 2004; Almeida & Phene, 2004) and improve their economic performance (Berry, 2015).

1.2.3 The subsidiary factors

The MNE internal network and the external local environment are both potential sources of knowledge for subsidiaries. Nevertheless, the extent to which subsidiaries leverage these inputs to improve their performance ultimately depends on their own capabilities and choices. The subsidiary-level literature (Birkinshaw, 1996, 1997; Birkinshaw & Hood, 1998, 2000) has stressed the importance of subsidiary's own initiative and entrepreneurial orientation in defining its role and its development path. Subsidiaries with a high degree of autonomy and a distinctive ability to create and manage linkages with internal and external partners can initiate a gradual evolution of their R&D mandate to develop new competences for the entire MNE (Cantwell & Mudambi, 2005) and eventually become centers of excellence (Frost, 2001). The acquisition of new competences has a feedback effect on this subsidiary-driven dynamic process. The possession of valuable capabilities gives the subsidiary bargaining power inside the group (Mudambi & Navarra, 2004) and the possibility to successfully lobby for additional autonomy and resources, which in turn facilitate the development of new capabilities (Birknshaw & Hood, 1998). Subsidiaries with valuable capabilities are also in a better position to attract new collaborations within the MNE and with external partners interested in learning their know-how, thus stimulating a virtuous circle of knowledge generation.

Moreover, as suggested by the absorptive capacity view (Cohen and Levinthal, 1990), the accumulation of experiences and knowledge improves subsidiary's capability to recognize, absorb and apply new and valuable knowledge. In this perspective, subsidiaries' R&D initiatives increase their technical expertise and absorptive capacity. Local R&D facilities help the subsidiary to assimilate the know-how and technology assets transferred from the MNE network and adapt them to the characteristics of the local market (Un & Cuervo-Cazurra, 2008;

Kuemmerle, 1999; Belderbos et al., 2008). Subsidiaries with strong technological capabilities are also superior in sourcing and expanding the tacit knowledge situated in their location (Song et al., 2011). Once the local pool of knowledge becomes redundant, the development of high level sourcing capabilities may enable subsidiaries to extend their technological search also beyond their local boundaries to access distant and unfamiliar knowledge globally (Nobel & Birkinshaw, 1998; Asakawa & Lehrer, 2003; Frost, 2001). Following this evolution, subsidiaries may gradually take a central role in the formation of 'non location-bound' MNE specific advantages (Rugman & Verbeke, 2011).

1.3 Overview of the Dissertation

This dissertation contributes to the literature on subsidiary performance. As highlighted in the previous section, the roles and functions of MNEs' subsidiaries are multifaceted and constantly evolving (Birkinshaw & Hood, 1998). Hence, research needs to expand current understanding of the mechanisms influencing (different dimensions of) subsidiary performance. In this perspective, as subsidiaries are part of a network of geographically dispersed units that belong to the same organization, the MNE dimension can take a crucial role in defining subsidiary performance. At the same time, the characteristics of the local context in which the subsidiary operates, and the capabilities that the subsidiary develops over time, are important factors affecting the evolution of subsidiary operations. While these factors, the MNE, the local environment and the subsidiary, have been extensively studied separately, less work has been devoted to understand their interactions. Each of the three chapters of this dissertation explore how the interplay of these three factors affects a specific dimension of subsidiary performance.

This dissertation draws on, and contributes to, multiple streams of literature. Chapter 2 contributes to the innovation literature by investigating the performance of MNE R&D units in recombining (in ways new to the world) knowledge from multiple technological fields. Chapter 3 adds to the literature on productivity by studying how subsidiary local R&D activities and MNE R&D activities improve subsidiary productivity. Chapter 4 speaks to the literature on foreign divestments by exploring subsidiary survival under different environmental conditions. Finally, Chapter 2 and 3 also contribute to the discussion on the geographic distribution of R&D activities in the MNEs and the role of intra-MNE knowledge integration.

Chapter 2 deals with the generation of new knowledge by R&D units of MNE[1]. More specifically, it focuses on R&D units' performance in developing novel inventions that combine existing technologies in previously unexplored ways (Fleming, 2001; Arts & Veugelers, 2013; Verhoeven et al, 2016; Schumpeter, 1934). While this type of inventions are only a small fraction of the knowledge generated worldwide, novel inventions have the potential to be extremely impactful, opening up new technological trajectories for further developments. Further, they are important to overcoming the typical learning traps that can erode firm's long term competitiveness (Ahuja & Lambert, 2001). The existing literature has conceptualized the MNE as a network of geographically dispersed units with diverse and distant expertise (Kogut and Zander, 1992; Birknshaw, 1997). However, there is little empirical evidence on the actual ability of units to recombine unit-specific expertise and expertise elsewhere in the MNE to generate boundary-spanning inventions that depart from the existing technological paradigms. In this respect, the characteristics of the unit's intra-firm network of knowledge collaborations, i.e. the geographic spread and technological distance between nodes, are expected to influence the assimilation and exchange of knowledge originated from different regional innovation systems. This may provide crucial input to the search process for technological novelty.

This study uses patent data to construct the intra-firm knowledge network (the MNE factor) of units (the subsidiary factor) that are part of 168 large R&D intensive firms operating in 138 regions located in 30 different countries. A newly developed patent level indicator (Verhoeven et al, 2016) is used to measure the technological novelty created in each unit. Finally, additional analysis at the technological field level considers the role of the local environment (the local factor) by linking the technological specializations present in the regional innovation system with the technologies combined by the unit in novel ways.

Chapter 3 moves the attention from the creation of knowledge to its economic impact by looking at subsidiary performance in terms of labor productivity. More precisely, the study presented in this chapter analyzes the effects on subsidiary productivity of subsidiary local R&D and overseas R&D conducted in the MNE network, conditional on the pool of relevant knowledge present in the subsidiary's host country. The study explores the intertwined relationship of three factors by analyzing how local environmental characteristics (the local factor) affects how subsidiary local R&D (the subsidiary factor) and MNE internal knowledge

[1] It must be noted that Chapter 2 considers in the analysis all R&D units part of the MNE, thus also including domestic subsidiaries and HQ's R&D labs

(the MNE factor) contribute to subsidiary productivity. While an extensive body of literature has focused on the influence of R&D geographic distribution on MNE economic and innovation performance (Griffith et al., 2006; Lahiri, 2010; Kafouros et al., 2012), much less work has been done to explore these dynamics at the subsidiary level.

The study presents estimates of a dynamic productivity model on a large sample of foreign subsidiaries located in The Netherlands. The model is derived from an augmented knowledge production function where the subsidiary stock of knowledge depends on subsidiary local R&D investments and R&D investments in the MNE network. Subsidiaries are divided into two groups according to the distance of the host country industry environment from the global R&D frontier: subsidiaries that are active in industries at the frontier or behind the frontier. Individual and combined effects of local and MNE R&D investments are then estimated and compared across the two groups.

Chapter 4 takes subsidiary survival as a measure of subsidiary performance. This study investigates to what extent the MNE global strategic orientation (the MNE factor) may change the way in which local environment characteristics (the local factor) exercise pressure on subsidiary survival. Among host country characteristics that drive subsidiaries divestment decisions, the importance of high labor costs, i.e. cost factors, and declining local demand growth, i.e. demand factors (Benito, 1997; Delios & Beamish, 1999; Belderbos & Zou, 2007; Pennings & Sleuwaegen, 2000) may depend on the MNE orientation toward global cost efficiency and integration of production. The MNE's strategic orientation and international configuration, in turn, is affected by the level of global market integration in the industry.
The study investigates, drawing on a large sample of Japanese manufacturing subsidiaries active in 56 countries, how different MNE orientations, in response to diverging trends in market integration, affect the importance of host country labor costs and market demand as drivers of subsidiary divestments.

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Chapter 2

Intra-firm network diversity and technological novelty in multinational firms' R&D units[1]

2.1 Introduction

In the current global economic landscape knowledge is considered as the main driver of growth. Knowledge intensive industries produce a continuous stream of innovations that can be either incremental or highly novel in their nature. The vast majority of inventions belong to the first group: they extend and refine already existing technological paradigms with limited overall impact. The second group of highly novel discoveries remains a very rare phenomenon. Yet, these discoveries are responsible for most of the observed disruptive technological changes (Arthur, 2007) and worth studying for their potential implications in society and markets. Studies show that novelty arises from the recombination of existing technologies in previously unexplored ways (Fleming, 2001; Arts & Veugelers, 2013; Verhoeven et al, 2016; Schumpeter, 1934). Inventions embedding principles that span multiple fields are more likely to be impactful as they become the basis for further inventions in the future (Rosenkopf & Nerkar, 2001 Schoenmakers & Duysters, 2010).

Complex and uncodified knowledge cannot be easily transferred and requires prolonged personal contacts and face-to-face interactions, which makes it less accessible from distant sources (Jaffe et al, 1993; Thompson & Fox-Kean 2005; Singh, 2005). Because of the intrinsic tacit nature of knowledge (Nelson and Winter, 1982; Polanyi, 1966), countries - and at a more disaggregated level, regions – tend to develop distinct kinds of technology profiles and knowledge clusters (Porter, 1990; Patel and Pavitt, 1991). In this regard, multinational corporations (MNCs) represent key actors endowed with the necessary resources to construct an intra-firm innovation network for the assimilation and integration of geographically dispersed knowledge (Kogut and Zander, 1992; Birknshaw, 1997). Although several studies have explored the relationship between the geographic distribution of firms R&D activities and their innovation output (Singh, 2008; Lahiri, 2010; Almeida & Phene, 2004; Phene & Almeida, 2008), little is known about the role of multinational firms and their dispersed R&D units in

[1] Earlier versions of this chapter have been presented at the Druid Conference (2017), the EIBA Conference (2017) and the University of Maastricht Innovation Workshop (2017).

producing novel inventions. The purpose of this study is to assess whether R&D units' geographic proximity to heterogeneous 'pockets of expertise' (Pnner-Hahn and Shaver, 2005) and knowledge transfer between units (Ghoshal, Korine, & Szulanski, 1994; Gupta & Govindrajan, 2000; Frost and Zhou, 2005) allow MNCs to generate novel inventions by combining a unique mix of technologies concentrated in distant areas.

Novelty is especially important for established firms to overcome learning traps that can obstacle the discovery of breakthrough inventions (Ahuja & Lambert, 2001). Firms that rely only on familiar solutions and focus only on mature technologies might see their competitive advantage eroded in the long term by new entrants that were more successful in experimenting with frontier knowledge. Previous literature has demonstrated that firms with higher innovation output quality also have higher market value. This positive relationship is driven mostly by few highly impactful inventions (Hall, Jaffe, and Trajtenberg, 2005). Technological novelty is an important predictor of these breakthrough inventions (Verhoeven et al., 2016; Fleming, 2001). Yet the high level of risk embedded in these projects might discourage firms from investing the optimal amount of resources. For this reason it is important for the firm to understand how to increase the chances of discovering novel inventions.

I posit that two characteristics of the MNCs knowledge network influence the technological novelty of their R&D units. First, the geographic scope of R&D collaborations pursued by each unit with the rest of the firm will broaden the range of localized skills and capabilities effectively shared and utilized in their R&D activities (Singh, 2008). The joint utilization of technological approaches acquired from distinct geographic origins may unveil new opportunities to integrate components from multiple technological fields. Second, the technological distance between the intra-firm connections also affects the transfer of information across geographic regions. The degree of knowledge overlapping in the network of collaborations will determine the spectrum of different expertise that can be accessed and recombined by the focal unit (Nooteboom, Haverbeke, Duysters, Gilsing, & van den Oord, 2007).

I empirically test the advantage of units with a cross-regional intra-firm network in place over units that limit their search to knowledge accessible within their local environment on a large patent-derived sample of R&D units of 168 large R&D-intensive firms located in more than one hundred regions around the world observed from 1996 to 2003. I move beyond previous studies that used patent counts and patent forward citations to observe innovation performance,

and I employ a direct measure of technological novelty that identifies the first appearance of two technologies together in one invention (Verhoeven et al, 2016). This allows me to shed light on the underlying mechanisms leading to recombination of technologies across different R&D units and geographic locations. In a supplementary analysis, I identify at fine-grained level the technological fields combined in the novel invention of the R&D units in the sample. I find that R&D units are more likely to recombine their fields of expertise with technologies from other fields if they can access the missing technologies via their intra-firm network of R&D units located outside their region.

In the following section I give a brief overview of the relevant literature, and I derive hypotheses on the relationship between MNCs R&D units' intra-firm knowledge network and their technological novelty. The subsequent section explains the data, variables and methods. I then present results for the analysis at the R&D level and for the supplementary analysis at the technological combination level. The conclusions and limitations of the present study are provided in the final section.

2.2 Theoretical Background and Hypotheses

2.2.1 Technological Novelty

Technological development and innovation are often understood as a cumulative process where major inventions tend to emerge from the synthesis of other existing minor inventions. Physical components and technical principals are built and combined in a recursive manner to meet social needs and to interpret newly discovered phenomena (Arthur, 2007). In this context, old ideas are used as inputs to generate new ones through their reconfiguration and assimilation (Weitzman, 1998; Nelson & Winter, 1982; Romer, 1994; Schumpeter, 1934). Yet, among the unlimited possibilities to recombine knowledge, only a small subset of them is responsible for technological discontinuities and shifts in existing paradigms. The technological novelty embedded in these discoveries is usually achieved from technical components and scientific principles that are connected for the first time (Hargadon & Sutton, 1997) in previously unexplored ways (Henderson & Clark, 1990). Their high impact can stimulate new economic activities and increase overall social welfare (Harhoff, Narin, Scherer, & Vopel, 1999; Trajtenberg, 1990; Christensen, 2013; Thusman & Anderson, 1986). From a knowledge-based perspective, it is important for the long-term competitiveness of the firm to put substantial innovative efforts and resources in the exploration of radical technological solutions (Grant, 1996; Ahuja & Lambert, 2001). However, the level of uncertainty and risk of failure attached

to these projects is very high (Fleming, 2001). Although possibly very impactful, most radical attempts must go through a lengthy process of transformation and further development before reaching their full potential (Rosenberg, 1976). Therefore, to capture the highest number of possible game changer inventions, it is useful to identify their novelty *ex-ante* (Verhoeven, Bakker, and Veugelers, 2016). In general, novel innovations distinguish themselves from the existing knowledge in the way they combined the single elements that make the invention in previously unexplored ways.

2.2.2 Boundary-Spanning Innovation

Firms' innovation processes tends to be path-dependent as firms are inclined to find solutions in areas in which they already have accumulated knowledge and experience (Stuart & Podolny, 1996; Nelson & Winter, 1982). Local search in fields where the organization has high absorptive capacity eases the learning process and facilitates efficient problem solving (Cohen & Levinthal, 1990). Yet firms risk to fall into the *familiarity trap* and to stop experimenting with new technologies since they might not seem convenient in the short-run. That would hamper the ability to face future radical changes that could require the possession of a richer set of skills (Ahuja & Lambert, 2001). Partially in contrast with that, Fleming (2001) uses patent data to show that it is still possible to increase the outcome variance of inventions by combining 'familiar components' as long as they are connected in new ways. Nevertheless, the literature in general tends to agree with the idea that successful path-breaking inventions come from boundaries-spanning technological search (Jung & Lee, 2016; Rosenkopf & Nerkar, 2001). Rosenkopf and Nerkar (2001) look at patents granted in the field of optical disk technology and find that patents that cited previous patents in other technological fields are more likely to become the basis for future inventions across multiple domains. Similarly, Phene and coauthors (2006) look at biotech patents and find that the number of non-biotech patents cited by biotech patents is positively correlated with the citing patent likelihood of becoming a breakthrough invention. Finally, more novel inventions are more likely to source from multiple technological domains that are dissimilar from each other (Dahlin & Behrens, 2005; Schoenmakers & Duysters, 2010).

2.2.3 R&D Geographic Distribution and Knowledge Integration

The construction of a broad knowledge base might stimulate firms' inventive process by providing organizations with a wider set of existing competences that can be combined. Inventions' applications can be manifold and spill into multiple domains, this cross-fertilization of diverse technological trajectories helps the firm to persistently innovate across its knowledge

base (Cohen & Malerba, 2001; Suzuki & Kodama; 2004). However, specialized knowledge is expected to concentrate geographically in the presence of agglomeration economies and specific resources necessary for the innovation process (Cantwell & Jane, 1999). Uncodified and complex knowledge tends to be tacitly held by local experts, which makes it difficult and costly to transfer across long distances. The regional shared culture, its common practices and stable environment make face-to-face interactions and exchange of ideas within local social networks easier (Saxenian, 1994). Therefore, knowledge spillovers remain to a large extent geographically bounded (Jaffe, et al., 1993; Audretsch & Feldman, 1996; Singh, 2005). This ultimately gives rise to specialized national innovation systems and regional technological clusters (Cantwell, 1989; Porter, 1990).

The potential to discover path-breaking inventions from novel connections between different localized expertises is high, but remains problematic to accomplish due to the difficult task of moving complex knowledge across distant clusters. In this regard, MNCs are considered intrinsically more efficient than other mechanisms to transfer and use knowledge across distant locations (Hymer, 1960; Caves, 1971). Scholars in international business often see MNCs as globally distributed innovation networks capable of generating and integrating knowledge on a worldwide basis (Bartlett & Ghoshal, 1989; Kogut & Zander, 1993; Hedlung, 1994). Literature in this field has identified several mechanisms including personnel rotation, network-focused incentive systems, corporate socialization practices and joint projects that can boost the transmission channels of information between units (Frost & Zhou, 2005; Gupta & Govindrajan, 2000). The effective combination of formal and informal intra-firm mechanisms to transfer and share knowledge acquired from localized spillovers (Ghoshal, Korine, & Szulanski, 1994; Gupta & Govindrajan, 2000) permits multi-unit firms to source from a unique mix of technologies bounded to distant locations (Singh, 2008).

Within this framework, subsidiaries can be seen as simultaneously embedded in two distinct contexts: the local innovation system and the firm's intra-organizational network (Andersson et al, 2001, Meyer et al., 2011; Mudambi et al., 2014). By virtue of their position, MNCs sub-units can get in contact more easily with local actors that possess regional know-how. Several studies that use patent citations find empirical evidence of knowledge outflows from the host country to the MNC (Branstetter, 2006; Frost & Zhou, 2005), which can outweigh spillovers from the MNC to the host country (Singh, 2007). There are numerous mechanisms that MNCs can use to benefit from local knowledge: they can develop distinctive competences by establishing relationship with suppliers or by meeting particular needs of their costumers based

in the region. Another channel to obtain regional expertise is to attract local talents to work in their R&D units (Almeida and Kogut, 1999; Singh, 2007, 2008). Almeida and Kogut (1999) in their study find that diffusion of tacit knowledge increases with intra-regional labor mobility of skilled engineers. The sharing of knowledge is promoted also via joint projects with indigenous firms and/or scientific collaborations with public institutions (Griffith et al. 2006; Criscuolo and Autio, 2008). In geographic areas with some relative technological advantage, R&D units that search knowledge within their local environment can become more creative and less reliant on the headquarter directions in their innovative activities. In these cases, the sub-unit's mandate can take an active competence-creating role (Cantwell and Mudambi, 2005).

2.2.4 Network geographic spread

The innovation produced by these 'centers of excellence' part of the firm (Frost et al, 2002) is not only applied to the host market, but has a value for the entire MNC (Frost, 2001; Almeida, 1996). A specialized unit must establish active links with the rest of the organization to be able to benefit from the valuable innovation developed by other subsidiaries elsewhere. By keeping intra-firm collaborations across multiple regions, units get in contact with technologies and processes that were developed in different environments (Phene et al., 2006).Interacting with R&D personnel from different locations also reduces the risk of 'group-think' in the innovation process by challenging familiar solutions with external critical views and new ideas. Even when distant units are active in the same sector and rely on similar technologies, the heterogeneous institutional contexts in which they operate can provide non-overlapping skills. The organization of public R&D, the mechanisms to transfer knowledge from the scientific community to the industry and the structure of the manufacturing base active in the region can influence the technological developments of different sectors across locations (Fontes & Novais, 1998). A local unit might learn a new method to work on a known technological principle through another distant R&D unit that developed it to meet certain needs specific to its location. Subsequently, the first unit might find a solution to a new problem by integrating the acquired method with knowledge present in its region in a setting different from what it was originally conceived for. Thus, units benefit from the unconventional mix of approaches available through their collaborations as those can lead units to find novel technological solutions. Since the pool of knowledge the unit can get access to increases with the spread of collaborations, also the benefits increase. However, after a certain number of collaborations, redundancy in the know-hows obtained from the collaborations might also increase. Therefore,

we can expect the novelty benefits to increase with intra-firm knowledge network geographic spread, but at a decreasing rate.

At the same time, intra-firm collaborations with other R&D units entail certain costs that tend to increase exponentially with their geographic spread. Cross regional collaborations usually involve different time zones, cultures and languages. These factors make it difficult to create a common context via frequent face to face interactions and iterative learning. Without a common context, team members from distant R&D units might struggle to identify the constraints and conditions that other members are facing, thus increasing additional tasks and risk of personal conflicts (Hinds & Bailey, 2003). In addition, regions tend to differ in the criteria of reciprocity for exchanging information (Bianchi and Bellini 1991) which may further reduce the mutual understanding between distant researchers. Because of these impediments, R&D units incur in coordination and communication costs to maintain projects with cross-regional teams of researchers.

Moreover, a large network also increases the search costs to locate useful knowledge among all collaborating units. As the network of collaborations spreads, also the sources of knowledge increase with the risk of information overload. The transfer and decoding of complex and tacit knowledge is costly (Cohen & Levinthal, 1990), and it becomes even more difficult via numerous weak ties (Gosh & Rosenkopft, 2015). The resources necessary to understand and recombine the knowledge received from each connection tend to increase exponentially with the number of connections, making the recombination process excessively complex and costly to explore. At the micro level, researchers might have difficulties in knowing 'who knows what' and who can possess the necessary knowledge to solve a problem when the intra-firm network is overly spread. Information overload might quickly reduce the capacity and desire of researchers in the R&D unit to learn and integrate the external knowledge acquired by colleagues during their collaborations with other units (Shilling et al. 2003; Kirsh, 2000).

Thus, the geographic distribution of the knowledge network poses both benefits and costs to the R&D unit. The benefits of accessing geographically dispersed knowledge will increase (at a decreasing rate) with the spread of cross-regional collaborations and ultimately level off. The costs to manage the network, on the other side, will follow a convex curve and quickly escalate with network's spread. As a result, the novelty performance will initially increase with the spread of the collaborations, up to a point where coordination costs will outweigh the benefits

from geographically distant knowledge, then additional spread will decrease novelty. Therefore, I expect the following:

Hypothesis 1. The geographic spread of the R&D unit's intra-firm knowledge network is expected to have an inverted U-shape relationship on unit's novelty performance.

2.2.5 Network technological distance

Knowledge exchanged between R&D facilities located in distant geographic regions will depend also on their position in the technological space. Although the geographic distribution of R&D is in general associated with access to more technologies (Singh, 2008; Phene & Almeida, 2008), we must consider the actual knowledge possessed by each unit in the intra-firm network. The focal unit is stimulated to connect its expertise and knowledge with the diverse perspectives and specific capabilities brought in by the collaborating unit on unfamiliar domains (Nooteboom, et al, 2007; Gilsing, Nooteboom, Vanhaverbeke, Duyster, van den Oord, 2008). Units tend to develop expertise that reflects unique characteristics of their environments, thus a local unit is likely to absorb the most diverse knowledge from highly technologically distant units located in different regions. Establishing ties with units that have a different technological profile reduces cognitive redundancies and further increases the potential to generate novel combinations. The benefits from the exposure and interaction with dissimilar technologies increase linearly with the distance in the knowledge bases of collaborating units.

However, when the gap is too wide and there is no minimum understanding, the connected units might not be able to recognize opportunities to integrate their capabilities (Nooteboom et al., 2007). In order to succeed in novelty creation, R&D units have to develop an approach that departs from what it has been done so far in the world. New methods to assimilate distinct technologies are more difficult to invent as they deviate from the existing paradigm. The collaboration between pure specialists that have a depth knowledge on different technologies will likely generate challenges in the process of integrating them. Furthermore, the different geographic contexts can hinder the recombination process between too technologically dissimilar R&D facilities, since knowledge in fields that are not well understood becomes even more difficult to transfer and communicate with geographic distance (Lahiri, 2010; Penner-Hahn & Shaver, 2005). This will put an extra burden on the absorptive capacity of the unit as the cost to recognize, translate and apply dissimilar knowledge will increase exponentially with technological distance. Therefore, collaborating units should share, up to a point, knowledge

on multiple technologies and on the manner in which those technologies can function together in order to invent novel innovations. Therefore, I expect the following:

Hypothesis 2. The technological distance between the R&D unit and its intra-firm knowledge network is expected to have an inverted U-shape relationship on unit's novelty performance.

2.3 Data and Methods

2.3.1 Sample

My hypotheses were tested on a sample of 168 R&D intensive large multinational companies and their geographically distributed R&D units observed from 1996 to 2003. The firms were selected from the '2004 EU Industrial R&D Investment Scoreboard', which lists the top 500 European R&D spenders firms and the top 500 non-European R&D spenders firms. The companies' headquarters were situated in US, Japan and 11 European countries (i.e. Germany, France, United Kingdom, The Netherlands, Finland, Sweden, Denmark, Belgium, Switzerland, Spain and Croatia) and operated in 5 different industries (i.e. pharmaceuticals, chemicals, IT hardware (computers and communication equipment), engineering and mechanical machinery, and electronics). Both regions of origin (US, Japan and Europe) and industries are almost equally represented in the sample. For each selected company annual reports were consulted to obtain yearly financial data and to track possible changes in the group structure due to acquisitions, mergers and/or greenfield investments. The list of majority owned subsidiaries was further integrated with information retrieved from the 10K filings of US firms and information from the 'Directory of Japanese Overseas Investments' published annually by Toyo Keizai for foreign subsidiaries owned by Japanese firms.

To explore how the intra-organizational network can affect the innovative combinatorial capabilities of multinationals' R&D units, we retrieved all patents assigned to the focal firm and its subsidiaries from the PATSTAT (2013 version). Several studies have proved the validity of patents as a proxy for firms' innovative effort (Belenzon & Patacconi, 2013; Griliches, 1998). Patent data are a widely used tool in research because of their extended availability and the rich amount of information contained in them on the invention's ownership, inventors and technological components embedded in it. They also present some drawbacks: only a fraction of the whole innovation output eventually gets patented and the incidence of patenting varies significantly across industries (Griliches, 1990; Hall, Jaffe, & Trajtenberg, 2005; Mansfield, 1986). In our empirical setting, however, the problem remains limited since the firms in our

sample are active in industries where patent propensity is relatively high (Arundel and Kabla, 1998).

Only 'international patent' applications filed under the Patent Cooperation Treaty were included in the dataset. The PCT offers a unified procedure to seek patent protection in each of the contracting states by filing only one application at the World Intellectual Property Organization (WIPO) which then has to be approved by each national patent office. These patents are recognized to be of high value (van Zeebroeck et al., 2011; Jensen et al., 2011) and are not subject to home bias (de Rassenfosse et al., 2013). This bias arises as firms tend to refer to the patent office of their domestic markets as their first choice when seeking for patent protection. For instance, if we had to look only at European patents, we would probably weight excessively the technological strength of European firms compared to their counterparts across the ocean. This consideration is crucial given the heterogeneous origins of our multinational companies and the distribution of their R&D activities in multiple countries. The PCT patents also show a consistent 'timeliness' since the application at WIPO becomes public 18 months after its priority date (de Rassenfosse et al., 2013). This characteristic overcomes the problem encountered with USPTO patents which, until 2001, were published with a considerable time gap only after they had been granted. Furthermore, patent applications have been shown to be a more comprehensive indicator of firms' innovative efforts and technological developments compared to patent grants (Leten, Belderbos and Van Looy, 2016).

Since data on the allocation of R&D resources across different geographic units tend to be systematically missing, I follow previous literature and I construct the firms' revealed geographic configuration of innovation activities based on the location of their patents (Belderbos et al., 2013; Almeida & Phene, 2004; Phene & Almeida, 2008; Griffith et al., 2006). To do so I rely on the OECD Regpat Database (February, 2016) that assigns each patent to a region based on the inventor's address. OECD countries, EU 28 countries, BRICS and South Africa[2] are regionalized at different levels of aggregation. I used the NUTS 1 level for EU countries[3] I aggregated at the level of federal states for US and prefectures for Japan, while for the remaining areas I used the OECD Territorial Levels 2 (TL2) division. The inventor addresses are more precise than the address of the patent assignees to identifying the geographic location of an invention since firms tend to put as assignees the corporate headquarter (Deyle

[2] The rest of the addresses are localized at the level of countries
[3] Except for Belgium, Czech Republic, Denmark, Greece, Finland, Croatia, Israel, Iceland, Portugal, and Slovakia which are treated as single regions.

& Grupp, 2005) or other units located in countries with favorable tax rates (Griffith et al., 2011) instead of the subsidiary that invented the patent.

I consider the MNC to be present with an active R&D unit in one region if and only if the MNC has filed at least 10 patents[4] invented in the region during the five years period preceding the observed year. Limiting the analysis to units with a certain minimum prior innovation output helps to identify actual R&D labs and to reduces the risk to include sporadic collaborations. When a patent has inventors from multiple R&D units (i.e. inventors that reside in different regions) the patent is assigned to each R&D unit. However, as regional demarcations follow administrative boundaries rather than real economic areas, there may be cases where a lab located in the proximity of a regional (or even country) border employs inventors having their residence address in the adjacent region. The cross-regional commuting pattern of these researchers would create in the sample an artificial duplication of the real R&D lab assigned to the location where they live. I try to correct for this problem by merging the patent activities possessed by one firm in two neighboring regions into a unique R&D unit if more than half of patents assigned to one region were co-invented with inventors from the other region. The unit resulting from this combination is subsequently assigned to the region that originally had the larger number of patents. By way of explanation, the firm Air Liquide has filed over the observed period a total of 430 PCT patents with at least one inventor residing within the NUT-1 region Ile de France, which includes the city of Paris, and a total of 39 patents with at least one inventor from the surrounding region Bassin parisienne. Among those 39 patents, however, 36 of them (92%) were co-invented with (at least) one inventor from Ile de France, so I expect Air Liquide to have its R&D center in Ile de France[5] and I assign to that unit the full set of 39 patents[6] with inventor(s) of Bassin parisienne. This leads to an unbalanced panel sample composed of 1138 R&D units of 168 MNCs active in 138 distinct regions in the period 1996-2003. The sample has a total of 5072 observations. The mean number of patents filed per year is 27 with a median of 9. The largest R&D unit is SIEMENS headquarter in Bavaria with an average yearly innovation output of 1129 PCT applications.

[4] In an unreported trial I experiment using a threshold of 5 and 15 patents respectively. Results remain qualitatively similar, though somehow less strong especially for the variable geographic spread.
[5] All patents had the assignee's address in Paris
[6] In this case there was already an overlap of 36 of them.

2.3.2 Dependent Variable

R&D unit novelty performance

I rely on international patent classification codes (IPC) assigned by WIPO to each patent as a proxy of the technological components and principles incorporated in the inventions (Verhoeven et al., 2016; Carnabuci et al., 2013; Fleming, 2007). The IPC is a hierarchical classification system that categorize patent technologies along 5 layers of detail: section, classes, subclasses, groups and subgroups. I use IPC groups, the second most disaggregated level with more than 7000 distinct categories, to capture the micro-level knowledge embodied in the invention. These detailed IPC groups have been further grouped in 35 technological fields using the classification system resulted from the joint effort of the Fraunhofer ISI, the Observatoire des Sciences and des Techniques and the French Patent Office (ISI-OST-INPI).These 35 fields can be further aggregated in 5 broader sectors: 'Chemistry', 'Electrical engineering', 'Mechanical engineering' and 'Other fields'. This nomenclature has been created to facilitate meaningful comparison between fields since it fulfills certain requirements such as a balanced size and an appropriate level of differentiation across them (Schmoch, 2008) and it has been widely used in previous research (Belderbos et al., 2013; Le Bas & Sierra, 2002).

Patents can be assigned to multiple IPC groups across more than one technological field. I identify all possible pairwise combinations of IPC-codes from different fields contained. Building on Verhoeven, Bakker and Veugelers (2016), I define an invention as novel if it includes at least two technological components (i.e. IPC codes) that have never been combined before considering the entire pool of inventions patented worldwide at the time. I slightly depart from the aforementioned work as I only retrieve recombinations of technological components spanning two of the 35 broader technological fields, thus I discard new connections occurring within a single field[7]. The latter, however, remains a small portion (roughly 11%) of all novel IPC pairs present in my set of patents signaling that novel approaches require companies to stretch their search into multiple domains. My dependent variable is the sum of novel patents (i.e. with at least one novel combination) applied by a focal R&D unit in one year. The event of discovering a new to the world application of two technological components in one invention is by its nature rare: only 5% of the 115'716 of patents filed by the R&D units during the observed period are novel[8].

[7] An example of a novel patent is provided in Appendix 1

[8] This figure is in line with what found by Verhoeven et al. (2016) over the entire patent population

Figure 1 provides an overview of the 35 fields reported in descending order according to the number of novel connections in which they are involved. Among the top 10 fields in terms of new combinations, 6 of them belong to the broader defined sector 'Chemistry' as almost half of the R&D units in the sample operate either in chemical or pharmaceutical industries. If we consider the proportion of novel patents in each field, 'Micro-structural and nano-technology' is the field with the highest share of novel inventions, consistent with the highly dynamic and multi-disciplinary nature of this emerging technology (Lavie & Drori, 2012; Jung & Lee, 2016). The matrix in Table 1 reports the novel combination frequencies in the five broader sectors. To further stress the boundary-spanning nature of this type of discoveries, it is worth noting that more than 60 percent[9] of total novelty occurs in inventions that integrate knowledge principles from two more generally defined technological sectors.

[9] The percentage is calculated by summing up the total amount of novelty reported in each cell minus the diagonal.

Figure 2-1 Distribution of novelty across fields

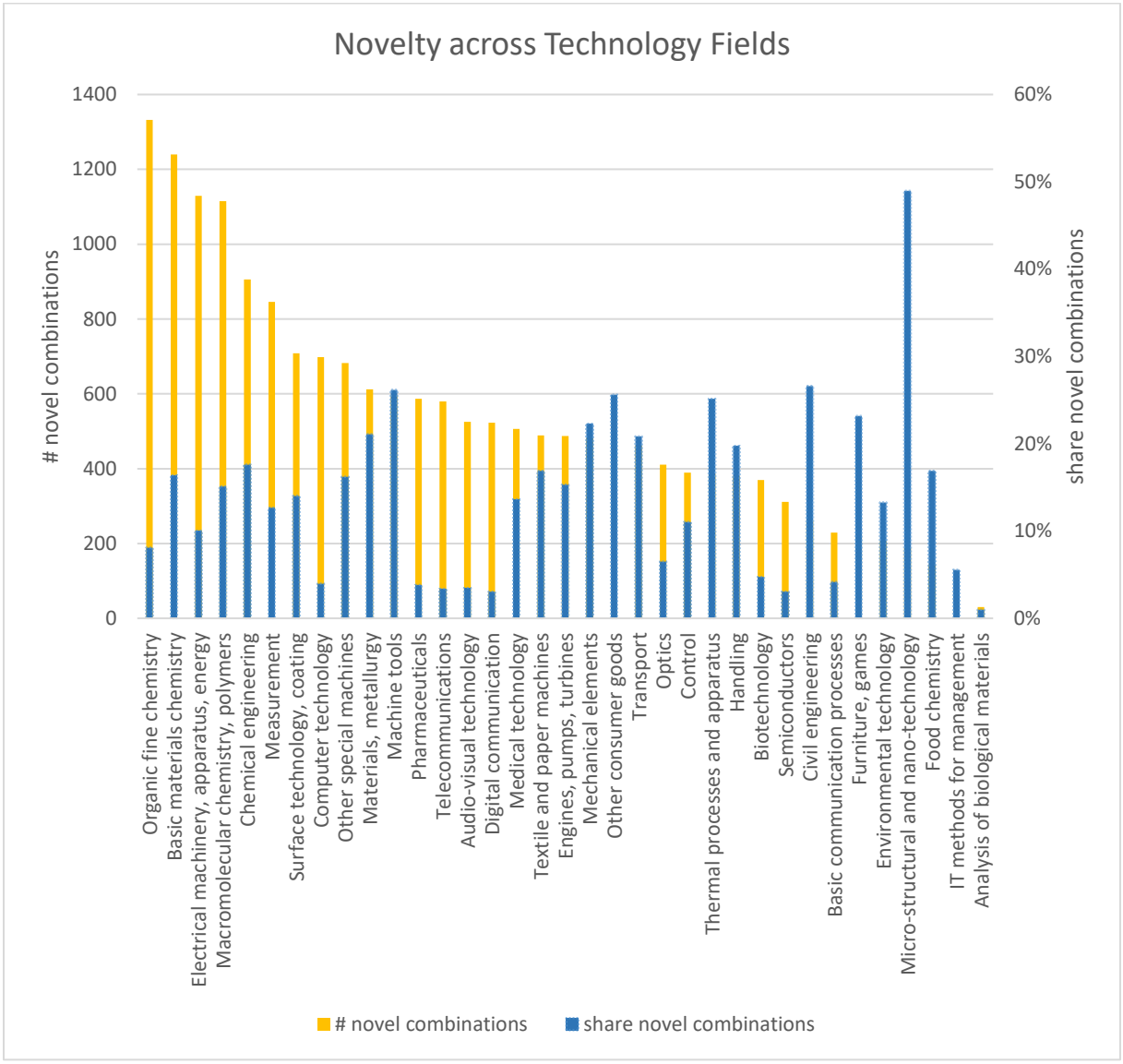


Table 2-1 Novelty between five broader technological sectors

	5 Sectors	1	2	3	4	5	total
1	Chemistry	2128	829	686	1416	253	5312
2	Electrical engineering		783	646	800	268	3326
3	Instruments			120	499	121	2072
4	Mechanical engineering				513	250	3478
5	Other fields					31	923

2.3.3 Explanatory Variables

Network Geographic Spread

I use co-inventions ties between inventors located in different regions as measure of the R&D unit intra-organizational knowledge network over time (Singh, 2008; Lahiri, 2010). Inventors involved in the same project tend to interact frequently and to invest substantial resources to facilitate significant knowledge transfer between each other. Several studies in the innovation literature have shown that scientific collaborations that result in patents reflect strong interpersonal-ties between co-authors that usually survive after the end of the project (Hansen, 1999; Nerkar & Paruchuri, 2005). In line with this interpretation, Frost & Zhou (2005) find that past joint R&D projects increase the likelihood of future knowledge flows between MNCs subunits.

To identify each R&D unit cross-regional ties with other units of the MNC in year t, I consider its 5-year patent portfolio, from t-5 to t-1, and I take as proxy of knowledge linkages patents with at least one inventor from another region in which the MNC is active with another unit. Then I use the Teachman (1980) entropy index to capture the geographic dispersion of the focal R&D unit intra-firm knowledge network:

$$Network\ Spread_i = \sum_{j \neq i}^{N} p_j * \log(1/p_j)$$

where p_j is the share of collaborations (co-invented patents) made by focal unit i with unit j over total number of collaborations made by focal unit i in the previous 5 years. The index can range from 0 to ln(N) where N is the number of regions the unit has collaborated with. This index takes larger values when the unit's collaborations are spread more evenly and across a larger number of regions. A quadratic term is added to test for curvilinear effects of geographic dispersion due to growing coordination costs in highly dispersed networks (Lahiri, 2010).

As I compute the *Network Spread* only on the set of R&D unit's co-inventions the index takes value zero when the focal unit has ties only with one partner (fully concentrate network) and it is missing in case the focal unit has no connections at all with other units. To solve this problem, I assign zero also to the isolated units without co-invention links and I add to the model a dummy variable *zero network* that takes value one for units with no collaborations outside of their region.

Technological Distance

To construct a measure that reflects the technological distance between the focal R&D unit and the rest of the intra-firm network, I employ the transformed cosine similarity measure proposed first by Jaffe (1986) and used in numerous other studies (Ahuja & Katila, 2001; Jung & Lee; 2016; Bloom, Schankerman, and Van Reenen; 2013). For each unit-partner pair I look at their 5-years patent portfolios and I measure one minus the technological similarity between the two, I then weight the distance by the strength of the collaboration link and I take the sum over all the focal unit's intra-firm inter-regional collaboration partners:

$$Technological\ Distance_i = \sum_{j\ (i \neq j) \in L} p_j \{1 - \left[A_i \cdot A_j' / \sqrt{(A_i \cdot A_i')(A_j \cdot A_j')} \right]\}$$

where A_i and A_j are vectors representing the distribution of patents across 35 technological fields in focal unit i and partner unit j patent stocks, while L is the set of units connected with unit i and p_j is the share of co-invented patents with partner unit j over all co-invented patents of unit i. The index has the favorable property of not being affected by units' scale and its value is bounded from a minimum of zero to a maximum of one. The higher the index, the smaller the technological overlap between focal R&D unit and its connections in the network. The co-invented patents that represent the knowledge linkage between two units are not considered for the computation of their technological proximity. Those patents cannot be considered knowledge external to the unit, since the unit also contributed, with its knowledge, to the development of those inventions. *Technological Distance* can take zero values in two circumstances: when the unit collaborates with intra-firm partners that have exactly the same technological profile, (this case does not occur in the sample) or when R&D units do not have any linkages with the rest of the MNC. A quadratic term is added to test for decreasing returns to novelty when too large distance can hinder effective exchange of knowledge between units (Nooteboom et al., 2007; Gilsing et al., 2008).

2.3.4 Controls

Region level controls

The breadth of technologies present in a region is also important in our empirical context. R&D units may increase their chances to combine internal expertise with local know-how in environments where the knowledge base is diverse and the set of available skills is distributed evenly across multiple domains (Castaldi, Frenken, and Los, 2015). To control for this local dimension, I construct a measure of *Regional Technological Diversity*. I calculate the entropy index = $\sum_j^N s_j * \log(1/s_j)$ where s_j is the share of regional patents in technological field j during

the previous 5 years and summed over the 35 technological fields. R&D units located in regions with a rich network of local firms and a large stock of available knowledge benefit from having access to expertise and localized spillovers (Almeida & Phene, 2004). Therefore, I include in my model *Regional Technological Strength* measured as the logarithm of total patents applied in the focal region[10] in the period from t-5 to t-1. I notice that this is a general measure of the technological strength of the location as it includes patents in all fields. An alternative would be to construct a measure that captures the strength of the location in the field in which the R&D unit is patenting. That would also allow to test whether the relative technological strength of the location influences the impact of the intra-firm knowledge network on R&D unit's novelty. However, R&D units seem to systematically patent in multiple technological fields: the observed median number of technological fields in which an R&D unit patents every year is 6 (out of 35). Moreover, the dependent variable novelty itself has a boundary-spanning nature as it represents the first recombination of two technological components that belong to two different technological fields. Therefore, it would be problematic to assign to each subsidiary only one industry for the definition of regional industry strength. Nevertheless, I do tackle this point in the supplementary analysis where I control for regional relative technological strength. In that case, as the analysis is at the level of technological field combination, I am able to define the strength of the region in each field that is potentially recombined.

Finally, I control for the R&D unit's degree of *local embeddedness* in the regional innovation system by adding the share of patents cited by the unit that were invented in its region (taking out self-citations) over total patents cited by the unit in the previous 5 years. Patent citations have been used by numerous studies as a revealed measure to identify the existing knowledge on which an invention is based (Criscuolo & Verspagen, 2008; Jaffe, Trajtenberg, & Fogarty, 2004). This measure should proxy for the intensity of unit's knowledge sourcing from indigenous innovation (Belderbos et al., 2013).

Unit level controls

Large units that produce a substantial amount of innovation are also more likely to report high levels of novel inventions as probability to eventually discover a novel combination may increase in the total number of invented patents. I control for this size effect by including in the model *Unit technological Strength* measured as the (logarithm of) total patents applied for by the focal unit in the previous 5 years. Units with a large technological breadth in their

[10] I exclude from the count patents owned by the R&D unit.

knowledge stock might benefit from their past experience in multiple fields in their knowledge recombination process. Therefore, I add a variable *Unit technological Diversity* using the entropy index described above computed over the unit 5-years patent portfolio. Another factor that can influence the generation of novelty is the time the unit has been active: on one hand, experienced units can use their accumulated knowledge in future innovation. On the other hand, young units are usually considered more dynamic and attentive to new technological opportunities (Klepper, 1996). Hence, I construct *unit age* as the (logarithm of) years elapsed from the first recorded patent application of the unit. Finally, prior studies have found that firms still conduct most of their basic and experimental research in their home based unit (Arora, Belenzon, and Rios; 2014). To account for that, I create a binary variable *main domestic R&D unit* that takes value one if the unit is the most innovative in its organization over the entire period and it is located in a region part of the MNC's home country[11]. I also control for knowledge inputs from external partners outside the firm (Nooteboom, et al., 2007; Phelps, 2010) by looking at patents with multiple applicants, i.e. co-patents, in which at least one applicant was not belonging to the firm group (Belderbos et al., 2014). I do this by comparing the assignee names in the patent with the consolidated list of assignee names link to the parent firm. I construct a variable '*external partners stock* 'as the (logarithm of) total unit's co-patents filed in the previous five years.

MNC level controls

I also control for other MNC's characteristics that might be correlated with unit technological novelty performance. First, I include *firm size* measured as the logarithm of parent firm's total turnover in year t-1. Empirical results on the effect of size on innovation remain mixed. On one side, the presence of economies of scale and scope increase innovation in large companies (Cohen & Levinthal, 1989). Novel inventions might have more chances to find an application in firms with a large market base. On the other side, increased size can cause inefficiencies, lack of control and disincentives for subunits to explore novel approaches in their technological search. Second, I control for *firm's R&D intensity,* i.e. R&D expenditures over sales, to account for MNC's innovative effort. Finally, I construct *firm novelty propensity* as the share of novel patents over the total number of patents filed by the firm over the previous five years. The R&D unit novelty performance might be the result of particular research strategies determined at the group level.

[11] I use this definition to identify R&D units located in the MNC's headquarter.

Region, Sector and Time Controls

I include in the model three sets of dummy variables to control for region, sector and year effects. First, region dummies account for unobservable time-invariant characteristics of the region that can affect the outcome in the dependent variable. For instance, regions with many universities might produce more basic research, which might correlate with units' propensity to undertake novel projects. Second, I consider the sector in which each unit patented the most during the previous 5 years as their main sector, I then use unit sector dummies to control for possible differences across domains in technological novelty. Finally, I include time dummies to account for factors specific to a certain year that can affect the output of novelty in that period.

2.4 Model Specification

Since the dependent variable is the positive count of R&D unit's novel patents, count models are preferred over linear models. I estimate a Negative Binomial model rather than a Poisson model because the dependent variable's conditional variance is larger than its conditional mean (Long, 1997). As I have longitudinal data, I follow the approach proposed by Blundell, Griffith and Van Reenen (1999) and I include among my covariates the pre-sample value of the dependent variable as pseudo unit fixed effects to control for individual unobservable characteristics. The pre-sample values should correlate with the time-invariant component that influence the observed novelty, while being exogenous to shocks taking place during the observed period and that can affect both the regressors and the error term. To do so I must look at novel patents filed by the R&D units between 1980 and 1990, since years from 1991 to 1995 are used already to construct the portfolio variables on the right side of the equation. I also add a dummy variable '*no pre sample'* that takes the value one if the unit filed the first patent after 1990 to control for zero pre-sample mean dependent variable due to late entry. This method is considered more flexible than standard fixed effects models that can yield bias estimates in short panels[12] (Greene, 2008). Moreover, the assumption of strict exogeneity necessary for both random and fixed effects estimators to be consistent is unlikely to hold in this setting. The independent variables are constructed using time windows of 5 years which makes the idiosyncratic error term of unit *i* in time *t* to be correlated with past and future values of the regressors. For instance, novelty success in year t may influence the future structure of the unit's

[12] The units in my sample are observed on average for 4.5 years. With fixed effects models information on 20% of the observation would be lost because a) unit appears only in one year b) the dependent variable reports only zero outcomes for the entire period.

network in year t+n as other units start to look for collaborations to develop the novel invention. In that case, the shock in the dependent variable in period t is transmitted in future periods through a feedback effect. Finally, I clustered the standard errors at the unit level to account for both over-dispersion and serial correlation in the error terms of the same unit (Cameron & Trivedi, 2009).

2.5 Results

Table 2 and 3 report the descriptive statistics and pairwise correlations for each variable used in the model. There seems to be no concerns of multicollinearity as the correlation levels between the independent variables are all below 0.6. The mean value of the dependent variable is 1.5 with a standard deviation of 4.5 and a maximum of 85 novel patents filed in one year. The average number of unit's patents filed each year (including not novel ones) is 27, thus the average share of novel patents relative to total unit patents is 5%. Since 55% of the observations have zero novel patents, the median R&D unit with 9 patents has zero novelty. The mean network geographic spread is 0.87 with a standard deviation of 0.69 while the technological distance index has a mean value of 0.3 and a standard deviation of 0.24. The R&D units observed in the sample that have not established any cross-regional linkages with the rest of the MNC network during the previous 5 years are 12%, while another 14% has collaborated with only one unit.

Table 2-2 Summary statistics for explanatory variables

Variable	Obs	Mean	Std. Dev.	Min	Max
novelty	5072	1,516	4,513	0	85
novelty share	5072	0,068	0,133	0	1
network spread	5072	0,873	0,690	0	3,25
network tech distance	5072	0,303	0,239	0	1
reg stock	5072	8,389	1,105	2,08	10,72
reg diversity	5072	3,252	0,113	1,43	3,44
local embeddedness	5072	0,079	0,143	0	1
external partners stock	5072	1,030	1,045	0	5,30
unit stock	5072	3,630	1,073	2,40	8,81
unit diversity	5072	1,553	0,616	0	3,10
main domestic R&D unit	5072	0,200	0,400	0	1
unit age	5072	2,485	0,501	0,69	3,26
parent novelty int	5072	0,059	0,049	0	1
parent size	5072	16,475	1,167	10,478	18,445
parent R&D int	5072	0,083	0,079	0,004	1,838
pre novelty	5072	0,168	0,456	0	6,5
no pre sample	5072	0,358	0,480	0	1
no network	5072	0,120	0,325	0	1

Table 2-3 Correlation table

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	novelty																
2	network spread	0,26															
3	network tech distance	0,00	0,11														
4	reg stock	0,05	0,01	-0,06													
5	reg diversity	0,06	0,00	-0,01	0,14												
6	local embeddedness	-0,03	-0,07	-0,06	0,27	-0,10											
7	external partners stock	0,39	0,26	0,08	0,22	0,07	0,05										
8	unit stock	0,55	0,39	-0,11	0,16	0,05	0,01	0,54									
9	unit diversity	0,29	0,09	-0,01	0,16	0,06	0,05	0,32	0,45								
10	main domestic R&D unit	0,29	-0,18	-0,17	0,17	0,01	0,02	0,27	0,40	0,29							
11	unit age	0,20	0,15	0,09	0,21	0,09	-0,07	0,34	0,39	0,33	0,24						
12	parent novelty int	0,03	-0,04	0,05	0,02	0,01	0,03	0,03	-0,03	0,08	0,04	0,07					
13	parent size	0,10	0,52	0,23	-0,14	0,00	-0,06	0,13	0,09	0,04	-0,35	0,01	-0,08				
14	parent R&D int	-0,05	0,01	-0,14	0,10	-0,07	0,04	0,03	0,07	-0,15	0,05	-0,13	-0,17	-0,16			
15	pre novelty	0,36	0,19	0,01	-0,01	0,00	-0,03	0,22	0,35	0,20	0,17	0,29	0,05	0,04	-0,01		
16	no pre sample	-0,13	-0,06	-0,12	-0,11	-0,03	0,06	-0,27	-0,28	-0,26	-0,21	-0,77	-0,09	-0,02	0,15	-0,27	
17	no network	-0,05	-0,47	-0,47	0,06	0,01	0,07	-0,15	-0,12	0,04	0,34	-0,07	0,06	-0,38	-0,04	-0,06	0,04

Table 4 reports the results of the analysis on the determinant of unit novelty. The control and explanatory variables enter the negative binomial regression equation in four separate steps. By adding my variables of interest one at a time, I control for potential issues of instability in the point estimates and standard errors of the coefficients. Model 1 includes only the control variables, while the hypotheses are tested in Models 2 to 4. The presence of the independent variables network geographic spread and technological distance, whether they enter the equation separately or jointly, increases the explanatory power of the model as indicated by the statistical significance of the Log-Likelihood ratio tests. In all Models, the coefficient of pre-sample novelty is positive and significant, explaining the unit's current ability to recombine technologies in novel ways.

In Model 1 we see that the characteristics of the local environment do not play an equal role in the unit's production of novelty. Only the coefficient of regional technological diversity is statistically significant and positive, indicating that the overall technological strength of a region is not enough to provide a fertile ground for novel inventions if that is not distributed evenly across multiple fields. Specifically, holding the other variables constant, one standard deviation increase in regional diversity would change the unit's novelty incidence rate by a factor of 1.16[1] (increase of 16%). The revealed degree of local embeddedness is not statistically significant which suggests that the orientation toward knowledge created in the regional innovation system does not affect the novelty of the R&D unit[2]. Turning to the unit level characteristics, large units that have experience in multiple fields are more novel. Also the of degree of collaborations with external partners appears to contribute to the novelty output of the R&D unit, although the coefficient is not very stable across all specifications and seems to lose importance once I control for technology distance with intra-firm collaborators. Being the main domestic R&D unit of the firms has also a positive and statistically significant effect on novelty performance as it increases its expected value by 36%. Looking at firm's level controls, the dependent variable is strongly correlated with past propensity in the MNC to discover novel inventions, reflecting a persistent approach employed at the group level to novel research. While, firm size does not have an effect on novelty. The only counter intuitive results is the negative effect of R&D intensity, which has been found also by Singh (2008) in his work on

[1] From the coefficient estimate of 1.31 in model 1 and a standard deviation of regional diversity of 0.11
$e^{(1.31*0.11)} - 1 = 0.16$

[2] In non-reported analysis I also tried to interact local embeddedness with regional technological diversity to test whether local embeddedness could have an indirect effect on novelty by reinforcing the direct effect of regional technological diversity but the interaction term was insignificant.

patent quality. A possible explanation could be that more R&D increases total innovation output by producing more incremental and less novel inventions on average.

Table 2-4 Results Negative Binomial model of R&D unit novelty

VARIABLES	Model 1	Model 2	Model 3	Model 4
network spread		0.248**		0.218*
		(0.109)		(0.111)
network spread2		-0.112**		-0.106**
		(0.045)		(0.045)
network tech distance			1.166***	1.127***
			(0.420)	(0.423)
network tech distance2			-1.269***	-1.202**
			(0.469)	(0.481)
reg stock	0.016	-0.062	0.014	-0.065
	(0.182)	(0.188)	(0.181)	(0.186)
reg diversity	1.311**	1.438***	1.327**	1.454***
	(0.544)	(0.539)	(0.544)	(0.537)
local embeddedness	0.039	0.029	0.026	0.011
	(0.200)	(0.200)	(0.201)	(0.202)
external partners stock	0.065**	0.071**	0.051	0.057*
	(0.032)	(0.032)	(0.032)	(0.032)
unit stock	0.609***	0.609***	0.626***	0.629***
	(0.033)	(0.035)	(0.033)	(0.035)
unit diversity	0.553***	0.552***	0.512***	0.511***
	(0.060)	(0.059)	(0.059)	(0.059)
main domestic R&D unit	0.318***	0.343***	0.320***	0.340***
	(0.078)	(0.080)	(0.078)	(0.079)
unit age	-0.134	-0.149	-0.141	-0.155
	(0.105)	(0.105)	(0.104)	(0.104)
parent novelty int	2.123***	2.144***	2.060***	2.081***
	(0.655)	(0.654)	(0.644)	(0.645)
parent size	0.041	0.040	0.032	0.035
	(0.029)	(0.032)	(0.029)	(0.032)
parent R&D int	-1.851***	-1.838***	-1.750***	-1.736***
	(0.666)	(0.666)	(0.628)	(0.627)
pre novelty	0.124*	0.139**	0.122*	0.138**
	(0.069)	(0.068)	(0.070)	(0.068)
no pre sample	0.083	0.075	0.092	0.086
	(0.102)	(0.102)	(0.102)	(0.102)
no network	-0.047	0.032	0.136	0.202
	(0.092)	(0.097)	(0.122)	(0.125)
Constant	-8.849***	-8.816***	-8.899***	-8.925***
	(2.508)	(2.518)	(2.509)	(2.516)
Over-dispersion parameter alpha	0.441***	0.439***	0.436***	0.435***
Observations	5,072	5,072	5,072	5,072
Log likelihood	-6269	-6265	-6264	-6260
LR test Model 2 vs Model 1		8.80**		
LR test Model 3 vs Model 1			10.90**	
LR test Model 4 vs Model 1				18.84***

Clustered standard errors at the unit level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year, region and unit sector dummies.

In Model 2 unit's network geographic spread shows a statistically significant curvilinear effect on technological novelty performance, confirming Hypotheses 1. Hypotheses 2, stating that the relationship between unit's technological distance with its network and novelty has an inverted U shape, is also supported in Model 3. In the full specified Model 4, Hypotheses 1 and 2 are tested simultaneously: both variables stay significant, although the linear term of Network spread becomes only weakly significant, with no substantial changes in the coefficients magnitude as they capture two distinct dimensions in the unit process of sourcing knowledge from distant locations. In Figure 2, I graph the effect of network geographic spread on novelty performance and I overlay the curve on the observed distribution of the network spread. The curve takes an inverted U shape and the inflection point beyond which the impact of network geographic spread reduces the expected innovation novelty[3] is at 1.03. Over the entire set of observations, roughly 57% of them have a network geographic spread below 1.03 with positive but decreasing effects of geographic dispersion on their novelty output. To move from 0 network geographic spread to its mean 0.87, increases the predicted novelty by 11%: from 1.46 to 1.63 expected novel patents. For the rest of the sample (43%) that lies in the down sloping part of the curve, the necessity to coordinate highly dispersed networks might eventually harm the search for new combinations. However, +1.5 standard deviations from the mean of network geographic spread, i.e. 1.91, the predicted novelty output is still 3% higher than what expected when units have only one or no cross-regional linkages.

I follow the same procedure to explore the relationship between unit's network technological distance and technological novelty performance. Figure 3 plots the predicted number of novel patents over different values of technological distance between 0 and 1. The histograms represent the observed distribution of technological distance. In this case, the inflection point where the effect on novelty start to be negative is reached at the distance of 0.47. Slightly more than three-quarters of the entire sample is in the range (0, 0.47). A jump from having no collaborators[4] to a mean network technological distance of 0.3 is associated with a proportional increase of 27% in predicted novel patents. In the range (0.47, 1), only less than 67 observations report distance above 0.9 with novelty predictions lower than what expected at the starting point 0. In general, the negative impact on novelty caused by an excessive technological distance

[3] In this case the predicted number of event (novel patents on the left y-axis) is the average of the predictions over the sample values and not the prediction at the means of the regressors. To obtain this, I fix only the variable network spread each time at different values in all the observations in the sample, then I estimate the model and I take the average of the predicted y.

[4] There are no observations in the sample with an active network formed by units with exactly the same technological profile

between collaborating units is shifted towards fewer extreme cases compared to what observed for network geographic spread.

Figure 2-2 Predicted Innovation Novelty over Network spread

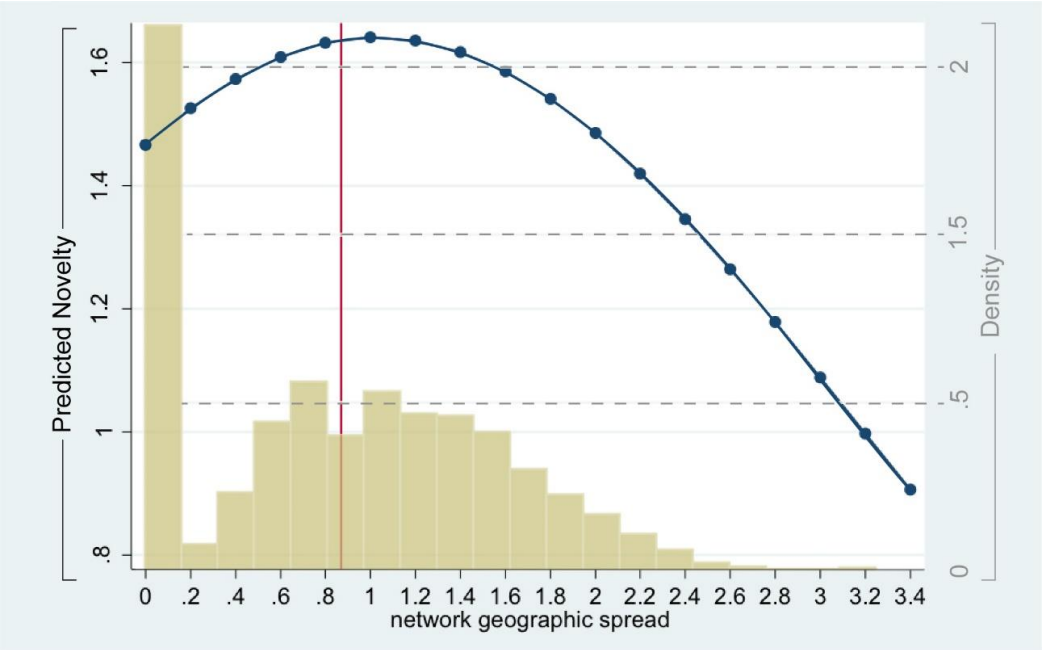
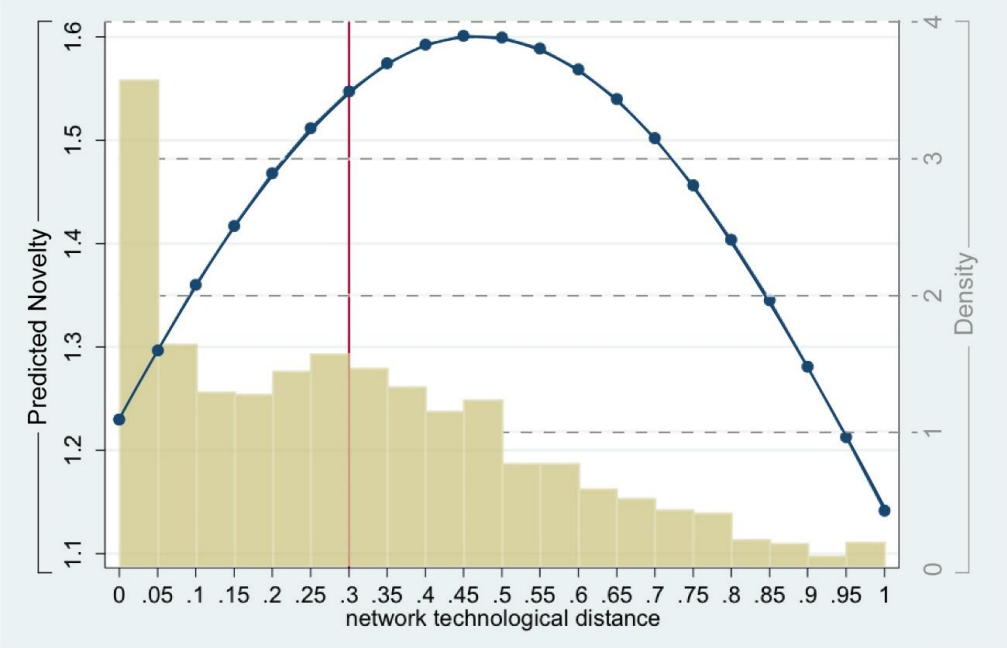


Figure 2-3 Predicted Innovation Novelty over Technological distance



2.6 Robustness checks

To assess the consistency of my results I conduct a battery of sensitivity checks reported in the Appendix. First, I look at the extensive margin rather than the intensive margin of unit's novelty. In more than half of the observations units file zero novel patents, while only for 24% of the cases there is more than one novel patent filed. The table in Appendix 2 shows the results of a probit model where the covariates are tested on the likelihood of a unit to discover at least one novel combination in the current year. The outcomes remain in line with our findings. The network spread and the technological distance of unit's intra-firm collaborators do show a statistically significant inverse u shaped effect already for the distinction between novel vs not novel units. Also the inflection points of the two variables are similar to the original model.

As a second sensitivity test, I try to replicate the analysis using an alternative measure of R&D unit's technological novelty. To do so, I construct the 'unconventionality' indicator developed by Silvestri (2017), and based on the work of Uzzi et al. (2013). This indicator is based on the degree of relatedness between two technological elements in the existing technological space (Breschi, et al., 2003; Nesta & Saviotti, 2005). Two technological elements (IPC codes) are seen as related to each other if they co-occur together in inventions more often than what we would expect if they were randomly drawn from the technological space. Inventions that are composed by less related technological pairs elements are, therefore, considered more unconventional. While the technological novelty measure identifies first instances of technology pair's recombination, which represent extremely unconventional cases, unconventionality considers every technology pairs that form a patent on a continuum from particularly unconventional to conventional. For each patent I calculate the median and maximum unconventionality value of the pairwise combinations of technology classes that form the invention[5]. Then, I take the average over the R&D unit patents filed in the year. Appendix 3 provides mode details on the derivation of the measure and the steps to aggregate it at the R&D unit level. Tables in Appendix 3 report OLS estimates with R&D unit's unconventionality median (A3.1) and R&D unit unconventionality maximum (A3.2) as dependent variables. Results are broadly consistent with the original analysis. Network technological distance has a significant curvilinear effect in both models, while the effect of network geographic spread emerges more strongly for the peaks of technological unconventionality, which are closer to the original measure of novelty.

[5] In line with the original model I only consider pair of classes that belong to two separate fields.

In the third sensitivity check, I experiment with different variations of the variable network geographic spread to test whether the declining effects on novelty are driven by occasional collaborations between units, 'weak linkages', which inflate the entropy index. Weak linkages might divert R&D unit's resources and attention from accessing relevant knowledge. Appendix 4 reports the sensitivity checks. In Model 1 and 2, I calculate again the unit's network spread index, considering only the first four unit's partners in terms of volume of patents co-invented together. Four represents the observed median of links among units with at least one link. This reduces the level of network spread assigned to large units that report occasional collaborations with many other units (the network spread mean decreases from 0.87 to 0.71) with the drawback that it does not use all information in the data. In Model 3 and 4, I use the Blau index as an alternative measure for network spread. This measure of diversity has been used extensively in the business literature (Lahiri, 2010; Singh, 2008) and it is calculated as 1-$\sum_{i=1}^{N} p_i^2$ [6]. The Blau index should suffer less from the potential issue of having weak linkages driving up the score of network spread since its maximum level has an absolute upper bound value of one as number of links tend to infinity. The results show in both cases an inverted u-shape effect of network spread on unit's novelty with turning points close to the ones obtained in the original model.

In the fourth sensitivity check, reported in Appendix 5, I estimate a conditional unit fixed effects negative binomial model as an alternative way to control for unit unobservable time invariant characteristics. The results of the fixed effects regression are statistically weaker but otherwise consistent with those reported in the original specification. The sign of the coefficients of both technological distance and geographic spread show an inverted u-shape relationship with novelty, however, the linear term of geographic spread does not reach statistical significance at conventional levels. As previously discussed, there are no solid theoretical arguments, in the present study, to support 'strict exogeneity' of the error terms necessary for fixed effects models to be valid, thus, these alternative results should be interpreted with care.

Fifth, I also try to take into account the multi-level structure of the data, i.e. unit, region and firm level variables, and I estimate a three-level hierarchical random intercept model using the mixed-effect negative binomial model. I consider random effects at the unit and firm levels while keeping regional dummies to control for regional fixed effects[7]. Appendix 6 reports the

[6] p_i is the share of co-invented patents with one specific partner over the total co-invented patents of the unit

[7] A more correct approach would be to estimate a cross-classified multi-level model since firm and regions are not perfectly nested with each other. However, this approach is highly computationally demanding and the model could not converge with high number of groups in both firms (168) and regions (138).

results of the mixed model, the coefficients of the independent variables remain very similar to the original model. The firm and unit's specific random effects appear significant at 0.15 and 0.11 with standard errors of 0.04 and 0.02.

Finally, in an unreported trial I attempt to group the R&D units according to the sector of the parent firm ('chemistry, 'electrical' and 'mechanical' engineering) to explore potential industry heterogeneities in the impact of intra-firm network on novelty performance. The results were qualitatively similar, though less pronounced, across the three sectors. The model appeared to have some difficulties in identifying the effects of the independent variables without the inter industry variation.

2.7 Supplementary Analysis at the level of technological combination

In this additional analysis I delve deeper into the underlying mechanism of R&D unit's knowledge sourcing across its geographically dispersed intra-firm network and its local environment. To do so I identify the technological fields with a new combination in each R&D unit's novel patent. Then, I investigate to what extent novelty results from the recombination of technologies which are available to the unit either through its network or in the region. In the first part, I provide some descriptive evidence of how frequently the fields' expertise used by units in their novel inventions matches the expertise observed in their environment and/or in their intra-firm network. In the second part, I consider all possible fields that a unit can combine with its own expertise and I econometrically estimate the effect of its network and its region technological strength in one field on the likelihood to succeed in a novel combination with that field.

I start by mapping unit technological strengths using their revealed technological advantage (RTA) index in each of the 35 fields this measure was first introduced by Soete (1987) and subsequently employed in several other works on firms and counties competitive advantage across technological sectors (Patel & Vega, 1999; Patel & Pavitt, 1991; Cantwell & Janne, 1999; Le Bas & Sierra, 2002). The index is defined as:

$$RTA_{ij} = \frac{P_{ij} \Big/ \sum_i P_{ij}}{\sum_j P_{ij} \Big/ \sum_{ij} P_{ij}}$$

where P_{ij} is the number of PCT patents in technological field *j* part of the unit *i* patents stock in year *t*[8]. The indicator represents the share of unit patents in one specific field over all patents in that field relative to the share of all unit patents over the total number of patents worldwide. The measure fluctuates around unity with a value higher than one indicating that the unit (region) is relatively specialized in the considered technological field compared to other units. Symmetrically, units (regions) with an RTA below unity in one sector have a comparative disadvantage. Although ranking units (regions) according to their specialization is in theory possible, it must be noticed that for units (regions) with small number of patents the index can become unstable and increasingly sensitive to yearly changes in the data (Cantwell and Janne, 1999). In these cases, the units tends to show either low or extremely high levels of specializations without necessarily reflecting a real higher order advantage in the sector. Therefore, I avoid constructing hierarchies and I only pose the condition that the RTA is above unity to define whether a unit possesses a competitive advantage in a specific field. By doing that I identify the core fields of each unit. The presence of expertise in the focal unit intra-firm network is defined by looking at patterns of technological specializations in the co-inventing units. A focal unit can access expertise in one field through the intra-firm network if and only if at least one of its collaborating units has an RTA above one in that domain. Finally, I also measure technological specialization in the region where a focal unit is active to control for expertise available in the location.

2.7.1 Descriptive evidence

After having defined core fields for each unit, I retrieve from all their novel patents the fields combined using (at least) one IPC6 technology pair for the first time. This leads to 747 R&D units distributed over 114 different regions[9] that combine in novel ways two different technological fields 11911 times. For each of the two combined fields, I identify whether the field is a core technology of *a)* the focal unit that invented the patent b) one of the other R&D facilities in the focal unit intra-firm network c) the region in which the focal unit is located. Table 5 summarizes and breakdown frequencies for the possible combinations of specializations. Only 31 percent of the times both technological components are in core fields of the unit that applied for the novel patent. In those situations, the unit should already possess the necessary know-how in-house to efficaciously integrate the two domains. The remaining

[8] The time subscript is not reported for the sake of notation simplicity.
[9] The number of R&D units is 35% lower than the first analysis as 391 of them do not file any novel patent during the observed period

novelty is created by units that succeed in connecting technological components they are not specialized in. The focal unit might acquire the external capabilities either from the rest of the firm active outside of the region or via the knowledge present in the location. To convey ex-post evidence to support this view, I observed how often the unit's intra-firm network does have a technological advantage to offer in the missing domain when the local region does not provide for it and vice versa.

Besides few exceptions where units succeed in connecting fields without having experience in any of the two, in the most frequent scenario (48 percent) units combine one of their core technologies with a field outside of their sphere of expertise. I limit my attention to this group that appears the most likely way of achieving novelty and for which complementarities with the network and the local environment are easier to detect. In Table 5 we can see that units are able to find capabilities they do not have in house *1)* in the intra-firm network 23 percent of the cases *2)* in the local environment 23 percent of cases and *3)* in both 22 percent of the cases. For the remaining 32 percent, R&D units manage to apply their technological strengths in other domains without the possibility to access the expertise in the external environment. In general, however, we observe that most of time complementary knowledge is indeed present in the unit's network and the focal region.

Table 2-5 Novelty at fields pair level

Times a unit combines two fields in a novel way		
Total	**11911**	
Both combined fields are among unit's core fields	3698	***31%***
only one field is among unit's core fields	5627	***47%***
neither of the two is among unit's core fields	2586	***21%***

Distribution of expertise in the missing field for combinations where only one field is among unit's core fields		
Total	**5627**	
expertise can be found only in intra-firm network	1281	***23%***
expertise can be found only in focal region	1278	***23%***
expertise can be found both in network and region	1245	***22%***
expertise can be found neither in network nor region	1823	***32%***

2.7.2 Econometric evidence

So far the descriptive evidence has looked only at the novelty that has already taken place between two fields, thus conditioning on successful cases. However, both the role of the intra-firm cross-regional network and the local environment as pools of expertise the unit can source from, must be validated by considering all potential combinations of technological fields that an R&D unit can explore. To do so I construct a sample with observations R&D unit-year-fields pair specific, where the field pairs are every possible combination between a R&D unit's core field and any other field and the dependent variable is a binary variable taking value one if the focal unit made a novel combination in that field pair. In a hypothetical case where there are only four technological fields [A, B, C, D] and unit *i* core technologies are in fields A and C, unit *i* will have four observations with technological pairs: [A-B, A-D, C-B, C-D], with the first element of the dyad being the unit's core technology. Overall, with 35 fields, the number of pairs each unit can potentially combine gets as high as 595. By conditioning on having one core technology in the pair, I attempt to reduce the excess of zeros in the dependent variable due to the un-relatedness of most fields with the activities carried out by the unit.

I run probit regression models of unit's likelihood to file at least one patent with a novel connection in year t between a core field and a non-core field on unit's intra-firm network considering also the focal region specialization in the non-core field. Both variables are dummies, i.e. network/focal region RTA above one in non-core field, with an expected positive effect on the dependent variable. An interaction term is added to test for potential substitution effects between the two external sources of knowledge. Having already expertise in the local environment could reduce the additional value of having access to it via the intra-firm network and vice versa. In that case, the coefficient of the main effects would be positive, while the interaction term would be negative. I control for unit's strength in both fields in the pair by including (logarithm of) the number of patents in the unit 5-years patent portfolio in core field, *patent stock core*, and non-core field, *patent stock non-core*. Only in 18 percent of the cases units filed at least one patent[10] in non-core field during the previous five years. The latter variable capture the relevance of the non-core field to the unit. Time and technology specific effects are controlled for by means of year dummies and two set of dummies for each field – core vs non-core - that form the pair.

[10] I add one to the patent count to have a value for the logarithmic transformation also when the count is zero.

2.7.3 Results

Table 6 reports descriptive statistics and pairwise correlations for each variable of the model. The full sample has a total of 709,562 possible unit-fields combination pairs. Because of the very rare nature of the phenomenon itself, novelty the dependent variable is zero in almost all cases, only 0.71 percent of the time we observe a new combination between two fields that form the pair. Although the very low frequency of positive outcomes might raise concerns on the reliability of the results, the absolute number 5,045 is still large enough to derive consistent estimates of our parameters with probit regression.

Table 7 shows the results of the econometric analysis, Models 1a and 1b include only regional dummies, Model 2a and 2b add firm dummies, and Model 3a and 3b comprises a full set of unit specific dummies to control for unit's unobservable effects on the likelihood to make novel inventions by combining internal expertise with other fields. Including unit level fix effects in the analysis causes a drop of 25 percent in the number observations because of perfect predictability of failure for units with only zero outcomes in the dependent variable. This could raise some concerns as we can expect the units with at least one novel patent in the remaining sample to be structurally larger and more diversified[11]. However, by presenting sequentially each specification with different set of dummies I show that the sign and significance of the coefficients of network and region specialization remain stable across the three models. The results suggest that units are more likely to combine their core technologies with another non-core technological field when they can access the unfamiliar knowledge via one of their connections. Moreover, the expertise found in their local region also has a positive effect on their chances to apply their core-technologies in combinations with other fields. The insignificant coefficients of the interaction term between network and region specialization across all the models on the right side of the table suggests that there are no substitution effects between the two external sources of knowledge, thus I proceed by commenting the results of the most parsimonious models with no interaction. The average marginal effects are reported in squared brackets as semi-elasticities and represent a proportional change in the probability to succeed in novelty due to a discrete change from zero to one in the independent variable. The change in the expected probability of novelty when there is specialization in the network is around 50 percent across all Models. While the percentage change in the expected probability of novelty when region specialization changes from zero to one range from 10 percent in Model

[11] In this subset the intra-firm network of collaborating units provide expertise in the non-core field 22 percent of the times (only an increase of 1% from the full sample), while the proportional frequency of local environment specialization remain the same.

1a and 2a to 11 percent in Model 3a. Finally, the results remain robust if I change the specialization threshold to RTA>2, if I substitute the regional specialization dummy with the continuous measure of regional RTA (in logarithm) and if dummy variables for each sector combination[12] are added to the Models.

Table 2-6 Summary statistics and correlations supplementary analysis

	Variables	**1**	**2**	**3**	**4**	**5**
1	Novelty(=1)					
2	Network Specialized in non-core	0,047				
3	Region Specialized in non-core	0,011	0,043			
4	Patent stock in non-core	0,168	0,238	0,056		
5	Patent stock in core	0,120	0,043	-0,015	0,414	
	Mean	**0,007**	**0.21**	**0.37**	**0,23**	**1,98**
	St. Deviation	**0,084**	**0.4**	**0.48**	**0,59**	**1,19**
	Min	**0**	**0**	**0**	**0**	**0,69**
	Max	**1**	**1**	**1**	**6,14**	**7,90**
	Total	**709562**				

[12]I limit the choice to 5 broader sectors as adding 595 dummies for each possible combination of technological fields would decrease substantially the proportion of positive events over total parameters necessary for the estimation to be consistent.

Table 2-7 Results probit model supplementary analysis

VARIABLES	Model 1a	Model 2a	Model 3a	Model 1b	Model 2b	Model 3b
Network specialized in non-core	0.163*** (0.016)	0.169*** (0.018)	0.170*** (0.019)	0.175*** (0.020)	0.179*** (0.021)	0.173*** (0.022)
AME ey/dx	[0.50]***	[0.52]***	[0.51]***			
Region specialized in non-core	0.032** (0.015)	0.030** (0.015)	0.036** (0.015)	0.042** (0.017)	0.039** (0.018)	0.039** (0.018)
AME ey/dx	[0.10]**	[0.10]**	[0.11]**			
Reg&Network specialized in non-core				-0.029 (0.028)	-0.025 (0.028)	-0.007 (0.029)
patent stock in non-core	0.258*** (0.010)	0.255*** (0.010)	0.248*** (0.012)	0.258*** (0.010)	0.256*** (0.010)	0.248*** (0.012)
patent stock in core	0.215*** (0.007)	0.218*** (0.007)	0.208*** (0.011)	0.215*** (0.007)	0.218*** (0.007)	0.208*** (0.011)
Region Dummies	YES	YES		YES	YES	
Firm Dummies		YES			YES	
Unit Dummies			YES			YES
Core field Dummies	YES	YES	YES	YES	YES	YES
Non-Core field Dummies	YES	YES	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES	YES	YES
Constant	-2.990*** (0.145)	-2.423*** (0.160)	-3.090*** (0.335)	-2.995*** (0.146)	-2.428*** (0.161)	-3.091*** (0.334)
Observations	709,562	693,630	531,792	709,562	693,630	531,792
Non-zero outcome (%)	5,045 (0.71)	5,045 (0.73)	5,045 (0.95)	5,045 (0.71)	5,045 (0.73)	5,045 (0.95)
Log likelihood	-23578	-23162	-22425	-23578	-23161	-22425

Clustered standard errors at the field pair level in parentheses *** p<0.01, ** p<0.05, * p<0.1

2.8 Conclusions

This study contributes to the literature on innovation in MNCs geographically distributed R&D activities (Singh, 2008; Lahiri, 2010) as well as to the literature on technological search and technological novelty (Verhoeven et al., 2016; Rosenkopf & Nerkar, 2001; Schoenmakers & Duysters, 2010) by providing a more comprehensive picture of the role played by intra-firm cross-regional knowledge networks in the creation of technological novelty. Most of the previous studies suggested an advantage of MNCs in innovating by combining diverse

knowledge from different locations. However, the impact of knowledge distance between R&D units that are part of the internal knowledge network of multinational firms on their actual novelty performance have not been considered. In this study I look at R&D units of 168 large R&D intensive companies and their intra-firm collaborations across regions. Both the geographic dispersion of the R&D units' network and the overlap of their knowledge base are simultaneously investigated to explain the capability of MNCs units to discover novel ways of combining technological elements from different fields.

The analysis reveals that the geographic dispersion of collaborations with other R&D facilities part of the MNC has a curvilinear effect on the novelty produced by the R&D unit. Cross-regional knowledge ties expose R&D units to technological approaches and technics that were developed in locations characterized by different innovation systems. Their integration can result in novel solutions that other local firms could not achieve without a dense intra-organizational network in place to facilitate the flow of complex uncodified knowledge from distant regions. However, large networks can imply an information overload to the R&D unit which hinders their ability to recognize relevant components to be used in combination with their existing knowledge. A substantial portion of observations was found on the downward sloping part of the curve as the effort required to build understanding around a new technological paradigm seems to favor the distribution of intra-firm collaborations across a positive but limited number of locations. Yet, units might still gain from a larger number of intra-frim connections when sourcing more conventional knowledge (Leiponen & Helfat; 2006).

I also find that knowledge distance between connected R&D units has a curvilinear effect on their technological novelty. R&D facilities located in different regions tend to reflect their environments in their technological specializations (Cantwell & Janne, 1999). A local R&D unit can learn how to apply its capabilities in technological fields that were not part of its knowledge base by interacting with its geographically dispersed intra-firm innovative collaborators as long as there is a minimum understanding between the two sides. Although we would expect units' novelty to benefit considerably from collaborations between units with different technological profiles, my findings suggest that a relevant portion of units are experiencing negative marginal effects as the technological distance with their intra-firm collaborators is beyond the estimated optimal level.

Strong empirical support for the role of MNC knowledge network in providing complementary knowledge to the R&D unit is found once the technological fields combined in the novel inventions are considered. In the second part of the paper I create a new empirical set up where the unit's likelihood to find novel ways to integrate its technological strengths with the expertise present either in its network or in the local environment is tested over potential combinations of unit technological expertise with all possible technology fields. R&D units appear to source more effectively from counterparts located in other regions and part of the same firm than from their local environment, though the technological strengths present in the region still offer significant stimulus to the novelty production of the unit.

The present research is not exempt from limitations: although I attempt to control for potential confounding effects, with the current empirical framework, the discussion is limited to conditional correlations between R&D unit's novelty performance and the characteristics of its intra-firm knowledge network as a direct causal link between cannot be established. Furthermore, a direct measure of units' (degree of) connection with their regional innovation system was not included in the study (Almeida, 1996; Frost, 2001). Another possible refinement to the analysis would be to capture how fields distance themselves in the technological space. That would allow to assess more accurately the true recombinant potential of expertise accessible by the R&D unit via its intra-firm knowledge network and local environment. Alternatively, new indicators of technological novelty and network technological distance could also be derived from text-matching on patents documents as in Arts et al. (2018). Another avenue for future research could look at indirect links between R&D units part of the same firm and see how the presence of structural holes in the network can affect the novelty performance. Finally, further research could explore complexities in the *intra-unit* network of people working in the unit. The learning and transfer of knowledge between units is performed via interpersonal transfer which add further passages and possible frictions in *inter-unit* flow of information (Gosh & Rosenkopf, 2015). Moreover, the way the knowledge is held within the unit in terms of knowledge overlaps between researchers, team compositions and individuals that function as gatekeepers could affect the capacity to source and recombine technologies and expertise from other units (Cohen & Levinthal, 1990). A study at the inventor level may be interesting to further understand these mechanisms at micro-level.

Despite its limitations, this study highlights the potential of MNCs R&D units' network to recombine geographically bounded expertise. R&D units should not limit their function to outposts for the assimilation of indigenous knowledge or as means to transfer firm's internal

capabilities to new markets (Kuemmerle, 1999). MNCs must create and leverage knowledge ties across their R&D units to succeed in creating novel inventions from multiple technological domains on a global scale: a crucial challenge for firms that face competition in international markets and therefore must stand at the technological frontier globally.

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Appendix

Appendix 1

Example of technological novelty

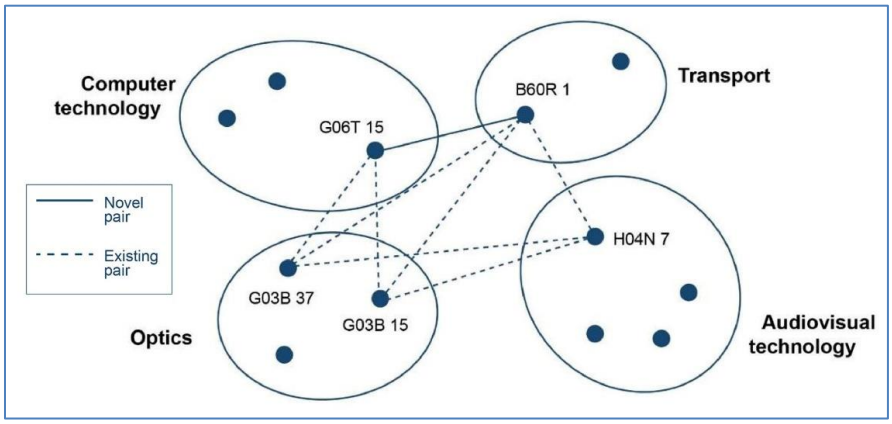
Here I use a novel patent filed by Panasonic to illustrate the concept of technological novelty. The patent refers to an invention of a monitoring system that can be used while driving a vehicle based on image processing techniques for generating synthetic images from multiple cameras located on the vehicle. The patent has been assigned to five different IPC codes, which represent the technological components of the invention and are grouped into four broader Schmoch (2008) technological fields (in brackets). The figure below visualizes all the combinations of technological components created by the invention. The patent classes *B60R001* and *G06T015*, which are connected by a continuous line, have never been combined before in one invention. This represents a novel combination which can be seen as the creation of a new 'technological bridge' between the fields of *Transport* and *Computer technologies*. The dash line that connects the other classes indicates combinations that have already been experimented in previous patents. The other dots in the circles are technological components which have yet to combine and represents potential for future novelty.

Patent international publication number: **WO2000064175**

Title: Image processing device and monitoring system
Assignee: Panasonic Corp **Priority date: 1999-04-16**

IPC codes:
G03B037: Panoramic or wide-screen photography ***(Optics)***
G03B015: Special procedures for taking photographs; Apparatus therefor ***(Optics)***
B60R001: Optical viewing arrangements ***(Transport)***
G06T015: 3D [Three Dimensional] image rendering ***(Computer technology)***
*H04N007: Television systems (****Audio-visual technology)***

Figure 2-A1 1 Example technological novelty: Patent WO2000064175



Appendix 2

Table 2-A2 1 Probit model for extensive margin of R&D unit novelty

VARIABLES	Model 1	Model 2	Model 3	Model 4
network spread		0.309**		0.291**
		(0.121)		(0.123)
network spread2		-0.135**		-0.132**
		(0.057)		(0.058)
network tech distance			0.896**	0.810**
			(0.398)	(0.399)
network tech distance2			-0.930**	-0.803*
			(0.446)	(0.452)
reg stock	0.182	0.176	0.187	0.177
	(0.217)	(0.220)	(0.218)	(0.221)
reg diversity	1.159**	1.191**	1.177**	1.216**
	(0.576)	(0.578)	(0.582)	(0.583)
local embeddedness	0.074	0.077	0.069	0.070
	(0.172)	(0.171)	(0.172)	(0.171)
external partners stock	0.073**	0.073**	0.064**	0.064**
	(0.031)	(0.031)	(0.031)	(0.031)
unit stock	0.420***	0.414***	0.436***	0.433***
	(0.037)	(0.038)	(0.038)	(0.039)
unit diversity	0.387***	0.391***	0.362***	0.368***
	(0.048)	(0.048)	(0.048)	(0.048)
main domestic R&D unit	0.246***	0.268***	0.241***	0.258***
	(0.085)	(0.085)	(0.085)	(0.085)
unit age	-0.076	-0.086	-0.087	-0.094
	(0.086)	(0.086)	(0.086)	(0.086)
parent novelty int	2.039***	2.041***	1.985***	1.991***
	(0.741)	(0.735)	(0.730)	(0.726)
parent size	0.039	0.029	0.032	0.024
	(0.025)	(0.027)	(0.025)	(0.027)
parent R&D int	-0.936**	-0.914**	-0.879**	-0.859**
	(0.397)	(0.395)	(0.377)	(0.373)
pre novelty	0.194**	0.197**	0.195**	0.199**
	(0.089)	(0.088)	(0.090)	(0.089)
no pre sample	0.039	0.032	0.046	0.042
	(0.087)	(0.087)	(0.087)	(0.087)
no network	-0.100	-0.011	0.043	0.120
	(0.081)	(0.085)	(0.106)	(0.110)
Constant	-7.990***	-7.950***	-8.067***	-8.078***
	(2.458)	(2.473)	(2.476)	(2.489)
Observations	4,982	4,982	4,982	4,982
Log likelihood	-2776	-2771	-2772	-2769
LR test Model 2 vs Model 1		8.50***		
LR test Model 3 vs Model 1			6.55**	
LR test Model 4 vs Model 1				13.97***

Clustered standard errors at the unit level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year, region and unit sector industry dummies.

Appendix 3

Derivation of Unconventionality measure

I borrow the notation of Silvestri (2017) to explain the operationalization of the measure unconventionality. Let the knowledge space consist of a set of Z patent applications assigned to T technology elements proxied by IPC-codes[13]. Let $C_{iz} = 1$ if patent *z* is assigned to the IPC-code *i*, and 0 otherwise. The total amount of patents assigned to the IPC code *i* is then $O_i = \sum_z C_i$, while the number of observed co-occurrences of IPC codes *i* and *j* is $J_{ij} = \sum_z C_{iz} C_{jz}$. To obtain the expected patents simultaneously assigned to IPC codes *i* and *j* under the assumption of random co-occurrence, I define a random variable X_{ij} that follows an hypergeometric distribution with mean μ_{ij} and variance σ_{ij} where:

$$\mu_{ij} = \frac{O_i O_j}{K}$$

and

$$\sigma_{ij} = \mu_{ij}\left(\frac{K - O_i}{K}\right)\left(\frac{K - O_j}{K - 1}\right)$$

The degree of relatedness between two technological components is then measured as the difference between their observed co-occurrence J_{ij} and their expected co-occurrence μ_{ij} normalized by their expected standard deviation σ_{ij}:

$$\tau_{ij} = \frac{J_{ij} - \mu_{ij}}{\sigma_{ij}}$$

where large values of τ_{ij} signify that patents assigned to both elements *i* and *j* are over-represented in the knowledge space, thus their combination has been experimented already several times and can be treated as conventional or incremental. On the contrary, a small or even negative τ_{ij} represents rather unexpected technology pairs. Their joint application in one invention would be quite novel considering their previous separate use. Relatedness τ_{ij} is calculated for every possible IPC code every year considering the population of patents (Z) present in PATSTAT and filed during the previous five years. The mean relatedness in the sample is 119 with a standard deviation of 150 and a minimum value (extremely unconventional combinations) of -50. The values are somehow more dispersed than what found in Silvestri

[13] I remain at the level of IPC groups ((6 digits) as for the original novelty measure.

(2017). However, direct comparison cannot be made as Silvestri (2017) focused on USPTO patents using USPTO technological classification, while here the measure is calculated over patents from all patent authorities using the international patent classification assigned by WIPO. The correlation between novelty and relatedness is -0.24 which is to be expected since novelty identifies combinations never made before, thus very distant in the technological space. Novel technology pairs have mean relatedness of -0.65 compared to 122 of not novel pairs.

From here, I transform the relatedness in unconventionality by adding one plus the absolute minimum level of conventionality, to avoid negative values, then I take the logarithm and multiply it by -1 so to have a measure that takes higher values when the technological recombination is less conventional. Then, I proceed by aggregating twice: first, at the level of patent, I take the median and the maximum unconventionality of all possible pairs of IPC-codes assigned to the patent. The unconventionality median considers the degree of unconventionality of all combinations within the single invention, while the unconventionality maximum takes into account only the most novel combination made. To be consistent with the original model I only consider IPC pairs that belong to two different broader technological fields. Second, I take the averages of the medians and maximums of patent's unconventionality across all patents filed by the R&D unit in one year and I obtain an R&D unit-year specific measure of unconventionality. For R&D units that did not file any patent with at least one cross-field IPC pair (unconventionality cannot be defined for those cases), I assign the minimum value of unconventionality observed in the sample (-7.32) and I add a dummy variable *'no cross fields patents'* to control for this effect.

Table 2-A3 1 OLS using median alternative measure of novelty (Silvestri, 2017)

VARIABLES	Median unconventionality Model 1	Model 2	Model 3	Model 4
network spread		0.059*		0.058*
		(0.035)		(0.035)
network spread2		-0.019		-0.020
		(0.015)		(0.014)
network tech distance			0.724***	0.696***
			(0.118)	(0.121)
network tech distance2			-0.605***	-0.562***
			(0.130)	(0.133)
reg stock	0.008	0.005	0.029	0.024
	(0.058)	(0.060)	(0.056)	(0.057)
reg diversity	-0.127	-0.110	-0.067	-0.047
	(0.161)	(0.160)	(0.159)	(0.158)
local embeddedness	-0.090	-0.085	-0.091	-0.088
	(0.059)	(0.059)	(0.058)	(0.058)
external partners stock	-0.007	-0.007	-0.018*	-0.018
	(0.011)	(0.011)	(0.011)	(0.011)
unit stock	-0.058***	-0.062***	-0.039***	-0.041***
	(0.011)	(0.012)	(0.011)	(0.012)
unit diversity	0.104***	0.105***	0.088***	0.089***
	(0.016)	(0.016)	(0.016)	(0.017)
main domestic R&D unit	0.044	0.051*	0.031	0.036
	(0.027)	(0.027)	(0.027)	(0.028)
unit age	0.046	0.044	0.039	0.037
	(0.029)	(0.029)	(0.028)	(0.028)
parent unconventionality	0.260***	0.261***	0.237***	0.238***
	(0.041)	(0.041)	(0.038)	(0.038)
parent size	-0.019**	-0.023**	-0.026***	-0.030***
	(0.009)	(0.010)	(0.009)	(0.009)
parent R&D int	-0.911**	-0.910**	-0.868**	-0.867**
	(0.355)	(0.355)	(0.336)	(0.336)
pre unconventionality	0.015	0.015	0.011	0.011
	(0.010)	(0.010)	(0.009)	(0.009)
no pre sample	0.079**	0.077**	0.082**	0.080**
	(0.035)	(0.035)	(0.034)	(0.034)
no network	0.048*	0.066**	0.194***	0.210***
	(0.028)	(0.030)	(0.036)	(0.036)
no cross fields patents	-2.702***	-2.699***	-2.712***	-2.710***
	(0.020)	(0.021)	(0.020)	(0.020)
Constant	-2.812***	-2.777***	-3.267***	-3.249***
	(0.738)	(0.739)	(0.720)	(0.720)
Observations	5,072	5,072	5,072	5,072
R-squared	0.779	0.779	0.782	0.782

Clustered standard errors at the unit level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year, region and unit sector industry dummies

Table 2-A3 2 OLS using maximum alternative measure of novelty (Silvestri, 2017)

VARIABLES	Maximum unconventionality			
	Model 5	Model 6	Model 7	Model 8
network spread		0.072**		0.071**
		(0.030)		(0.030)
network spread2		-0.026**		-0.027**
		(0.012)		(0.012)
network tech distance			0.410***	0.378***
			(0.104)	(0.106)
network tech distance2			-0.359***	-0.311**
			(0.118)	(0.121)
reg stock	0.044	0.038	0.054	0.046
	(0.050)	(0.052)	(0.050)	(0.051)
reg diversity	0.007	0.029	0.036	0.062
	(0.138)	(0.138)	(0.138)	(0.138)
local embeddedness	-0.018	-0.014	-0.019	-0.016
	(0.047)	(0.047)	(0.046)	(0.046)
external partners stock	0.006	0.006	-0.000	0.000
	(0.009)	(0.009)	(0.010)	(0.010)
unit stock	-0.048***	-0.051***	-0.038***	-0.040***
	(0.009)	(0.010)	(0.010)	(0.011)
unit diversity	0.075***	0.076***	0.064***	0.067***
	(0.014)	(0.014)	(0.014)	(0.014)
main domestic R&D unit	0.027	0.034	0.021	0.027
	(0.023)	(0.024)	(0.024)	(0.024)
unit age	0.046*	0.043*	0.041*	0.039
	(0.024)	(0.024)	(0.024)	(0.024)
parent unconventionality	0.137***	0.137***	0.130***	0.130***
	(0.027)	(0.027)	(0.026)	(0.026)
parent size	-0.012	-0.017**	-0.016**	-0.020**
	(0.008)	(0.008)	(0.008)	(0.008)
parent R&D int	-0.679**	-0.677**	-0.646**	-0.644**
	(0.270)	(0.271)	(0.259)	(0.259)
pre unconventionality	0.007	0.006	0.005	0.005
	(0.007)	(0.007)	(0.007)	(0.007)
no pre sample	0.045	0.042	0.047*	0.045
	(0.028)	(0.028)	(0.028)	(0.028)
no network	0.037	0.059**	0.116***	0.136***
	(0.025)	(0.026)	(0.032)	(0.032)
no cross fields patents	-3.007***	-3.004***	-3.012***	-3.010***
	(0.016)	(0.016)	(0.016)	(0.016)
Constant	-3.994***	-3.961***	-4.185***	-4.167***
	(0.646)	(0.645)	(0.643)	(0.642)
Observations	5,072	5,072	5,072	5,072
R-squared	0.832	0.832	0.833	0.833

Clustered standard errors at the unit level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year, region and unit sector dummies

Appendix 4

Table 2-A4 1 Sensitivity tests for weak linkages in unit's network

	Network spread limited to 4 links		Blau index	
VARIABLES	Model 1	Model2	Model 3	Model 4
network spread	0.429**	0.376*	0.741**	0.665*
	(0.215)	(0.218)	(0.339)	(0.343)
network spread2	-0.278*	-0.256*	-0.799**	-0.756*
	(0.151)	(0.152)	(0.399)	(0.398)
network tech distance		1.100***		1.101***
		(0.427)		(0.426)
network tech distance2		-1.186**		-1.183**
		(0.483)		(0.483)
reg stock	-0.008	-0.009	-0.029	-0.031
	(0.183)	(0.181)	(0.184)	(0.183)
reg diversity	1.402**	1.412***	1.417***	1.428***
	(0.548)	(0.547)	(0.545)	(0.544)
local embeddedness	0.043	0.027	0.034	0.018
	(0.199)	(0.200)	(0.198)	(0.200)
external partners stock	0.064**	0.051	0.067**	0.053*
	(0.032)	(0.032)	(0.032)	(0.032)
unit stock	0.603***	0.621***	0.606***	0.624***
	(0.034)	(0.035)	(0.034)	(0.035)
unit diversity	0.553***	0.514***	0.552***	0.513***
	(0.059)	(0.059)	(0.059)	(0.059)
main domestic R&D unit	0.340***	0.338***	0.341***	0.338***
	(0.079)	(0.079)	(0.079)	(0.079)
unit age	-0.140	-0.146	-0.144	-0.150
	(0.105)	(0.104)	(0.105)	(0.104)
parent novelty int	2.138***	2.075***	2.140***	2.078***
	(0.645)	(0.637)	(0.647)	(0.639)
parent size	0.034	0.028	0.038	0.032
	(0.030)	(0.031)	(0.031)	(0.031)
parent R&D int	-1.838***	-1.744***	-1.828***	-1.733***
	(0.669)	(0.631)	(0.666)	(0.628)
pre novelty	0.131*	0.129*	0.132*	0.131*
	(0.069)	(0.070)	(0.069)	(0.070)
no pre sample	0.081	0.091	0.078	0.089
	(0.102)	(0.102)	(0.102)	(0.102)
no network	0.038	0.196	0.049	0.208*
	(0.098)	(0.125)	(0.098)	(0.124)
Constant	-8.954***	-9.039***	-8.944***	-9.027***
	(2.538)	(2.536)	(2.522)	(2.520)
Over-dispersion parameter alpha	0.440***	0.436***	0.440***	0.436***
Observations	5,072	5,072	5,072	5,072
Log likelihood	-6266	-6262	-6266	-6261

Clustered standard errors at the unit level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year, region and unit sector dummies

Appendix 5

Table 2-A5 1 Negative binomial with conditional unit fixed effects

VARIABLES	Model 1	Model 2	Model 3	Model 4
network spread		0.206*		0.170
		(0.106)		(0.108)
network spread2		-0.107***		-0.099**
		(0.040)		(0.040)
network tech distance			1.029**	1.008*
			(0.507)	(0.516)
network tech distance2			-1.025*	-0.994*
			(0.568)	(0.579)
reg stock	0.309***	0.304***	0.309***	0.303***
	(0.105)	(0.108)	(0.104)	(0.107)
reg diversity	0.298	0.439	0.306	0.448
	(0.504)	(0.503)	(0.503)	(0.502)
local embeddedness	-0.111	-0.133	-0.104	-0.122
	(0.245)	(0.246)	(0.245)	(0.246)
external partners stock	-0.000	0.008	-0.004	0.006
	(0.040)	(0.040)	(0.040)	(0.040)
unit stock	0.299***	0.300***	0.300***	0.305***
	(0.050)	(0.050)	(0.050)	(0.050)
unit diversity	0.048	0.045	0.032	0.031
	(0.085)	(0.085)	(0.085)	(0.085)
main domestic R&D unit	0.268	0.421	0.306	0.445*
	(0.247)	(0.267)	(0.248)	(0.268)
unit age	-0.624***	-0.672***	-0.596***	-0.626***
	(0.207)	(0.207)	(0.204)	(0.205)
parent novelty int	1.071***	1.010**	1.062***	1.003**
	(0.411)	(0.415)	(0.411)	(0.414)
parent size	-0.021	-0.001	-0.016	0.007
	(0.070)	(0.071)	(0.070)	(0.072)
parent R&D int	-1.358	-1.473	-1.254	-1.410
	(0.912)	(0.908)	(0.916)	(0.910)
no network	-0.144	-0.082	0.017	0.076
	(0.112)	(0.114)	(0.143)	(0.144)
Year FE	YES	YES	YES	YES
Unit FE	YES	YES	YES	YES
Unit Sector FE	YES	YES	YES	YES
Constant	-1.532	-2.671	-1.870	-2.671
	(2.381)	(2.424)	(2.380)	(2.424)
Observations	4,045	4,045	4,045	4,045
Number of units	703	703	703	703
Log likelihood	-3959	-3953	-3957	-3953

Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year, region, unit and unit sector dummies. 1027 observations corresponding to 435 R&D units have been dropped because either they appear only once in the sample or they report all zero outcomes

Appendix 6

Table 2-A6 1Mixed-effects negative binomial model

VARIABLES	Model 1	Model 2	Model 3	Model 4
network spread		0.213**		0.185*
		(0.098)		(0.100)
network spread2		-0.109***		-0.103**
		(0.040)		(0.040)
network tech distance			1.064***	1.040**
			(0.412)	(0.420)
network tech distance2			-0.992**	-0.958**
			(0.462)	(0.473)
reg stock	0.201	0.108	0.188	0.092
	(0.166)	(0.170)	(0.165)	(0.170)
reg diversity	0.900*	0.990**	0.865*	0.953**
	(0.464)	(0.466)	(0.464)	(0.465)
local embeddedness	0.075	0.068	0.073	0.064
	(0.173)	(0.173)	(0.172)	(0.173)
external partners stock	0.070**	0.077**	0.064**	0.073**
	(0.030)	(0.031)	(0.030)	(0.031)
unit stock	0.568***	0.572***	0.582***	0.589***
	(0.032)	(0.033)	(0.033)	(0.034)
unit diversity	0.479***	0.476***	0.459***	0.456***
	(0.054)	(0.054)	(0.054)	(0.054)
main domestic R&D unit	0.396***	0.410***	0.387***	0.398***
	(0.078)	(0.078)	(0.078)	(0.078)
unit age	-0.107	-0.122	-0.115	-0.127
	(0.102)	(0.102)	(0.102)	(0.102)
parent novelty int	1.263***	1.242***	1.229***	1.201***
	(0.377)	(0.378)	(0.377)	(0.378)
parent size	0.005	0.002	0.001	0.000
	(0.038)	(0.038)	(0.037)	(0.039)
parent R&D int	-1.589***	-1.631***	-1.518***	-1.564***
	(0.440)	(0.441)	(0.436)	(0.438)
pre novelty	0.108*	0.130**	0.106*	0.127**
	(0.059)	(0.060)	(0.059)	(0.060)
no pre sample	-0.040	-0.046	-0.032	-0.037
	(0.098)	(0.099)	(0.098)	(0.098)
no network	-0.051	0.008	0.148	0.197*
	(0.085)	(0.089)	(0.112)	(0.114)
Constant	-7.738***	-7.327***	-7.601***	-7.216***
	(2.309)	(2.314)	(2.308)	(2.314)
Over-dispersion parameter alpha	0.223***	0.222***	0.223***	0.221***
Firm’s variance component	0.131	0.130	0.131	0.131
	(0.041)	(0.041)	(0.041)	(0.041)
Unit variance component	0.121	0.123	0.121	0.121
	(0.025)	(0.025)	(0.025)	(0.025)
Observations	5,072	5,072	5,072	5,072
Number of groups	168	168	168	168
Log likelihood	-6175	-6172	-6172	-6168

Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.The model estimates random intercepts for firm and unit levels.. Regressions include year, region, unit and unit sector dummies.

Chapter 3

R&D in Foreign Subsidiaries and the Global R&D Frontier: Evidence from the Netherlands[14]

3.1 Introduction

Knowledge that is rare and inimitable allows firms to progress and expand internationally (Grant, 1996; Kogut & Zander, 1993; Barney, 1991). According to standard international business theory, MNEs' technological advantages are developed at home, where most of the R&D activities are concentrated (Belderbos et al., 2013; Berry, 2014), and then transferred to foreign subsidiaries. Subsidiaries conduct R&D mostly to assimilate and adapt home based technological assets to the characteristics of their local market (Kuemmerle, 1997). Once successfully integrated, parent firm know-how helps subsidiaries to improve productivity and to establish a competitive advantage over local rivals (Buckley & Casson, 1976; Dunning, 1993; Caves, 1996; Hymer, 1960; Martin & Salomon, 2003; Delios and Beamish, 2001; Fang et al 2013; Fang et al , 2007; Fang et 2010) compensating for possible 'liabilities of foreignness' that arise from unfamiliar business environments (Zaheer, 1995). Empirical studies have confirmed a superior economic and innovation performance of foreign owned firms over domestic firms (Arnold & Javorcik, 2005; De Backer & Sleuwaegen, 2003; Guadalupe et al., 2012; Sadowski et al, 2006; Un, 2011).

At the same time, knowledge production has become increasingly globalized with new research hubs emerging around the world in multiple industries (Alkemade et al., 2015; Liu & Chen, 2012 Furman et al., 2002). As a result, some subsidiaries could be competing in national innovation systems where local firms possess more advanced technologies. In those cases, home based R&D might be less effective than local R&D in improving subsidiaries productivity. Local R&D activities could allow subsidiaries to gain access to the valuable tacit knowledge present in the host country (Cantwell & Jane, 1999; Singh, 2007; Song & Shin, 2008; Iwasa & Odagiri, 2004; Florida, 1997; Berry, 2006, Belderbos, 2003). Local knowledge can function as a vital input in the subsidiaries innovation process to increase efficiency and create more value through process and product innovation. Therefore, the relative contribution to subsidiary success of subsidiary local R&D efforts, in comparison and in combination with

[14] Joint work with Rene Belderbos (KU Leuven) and Boris Lokshin (University of Maastricht).

R&D conducted in the rest of the MNE network, will depend on the knowledge sourcing opportunities present in the subsidiary local environment.

Hence, the effectiveness and importance of subsidiary local R&D projects for subsidiary performance would be higher in host countries that offer an industry environment that is relatively more innovative compared to the rest of the world, and present high potential for knowledge spillovers. Industry environments with these characteristics can be considered at the global R&D frontier. On the other hand, if the host country does not present these conditions, and thus is lagging behind the global R&D frontier, the acquisition of technological assets developed in other MNE's R&D facilities located in more technologically advanced environments are likely to be more effective in improving subsidiary performance. The successful integration of these technologies, however, will still be linked to the individual ability of the subsidiary to absorb knowledge (Cohen & Levinthal, 1990; Penner-Han & Shaver, 2005). Local R&D activities are determinant for subsidiaries to build up the necessary capabilities to search, decode and apply to their operations the know-how and expertise of the MNE group. This is likely to generate complementarities (Cassiman & Veugelers, 2006; Kafouros et al., 2012) between subsidiary and MNE R&D activities that benefit subsidiaries productivity (Belderbos, et al., 2008)

While prior studies have suggested a potential positive effect of R&D geographic distribution on the financial and innovation performance of parent firms (Griffith et al. 2006; Belderbos et al., 2015; Penner-Han & Shaver, 2005; Todo & Shimizutani, 2008) and MNEs (Singh, 2008; Lahiri, 2010; Kafouros et al., 2012), less is known at the subsidiary level. Extant research using patent data have provided evidence for subsidiaries local knowledge sourcing and 'reverse' knowledge transfer from the subsidiary to the MNE when subsidiary host country has a technological advantage over MNE's home country (Frost, 2001; Singh, 2007). Studies have also established the importance for subsidiary innovation performance of knowledge sourcing from the host country as well as the MNE network (Almeida & Phene, 2004; Phene & Almeida, 2008). However, as a breakdown of subsidiary R&D expenditures data between R&D invested locally and R&D invested in R&D activities conducted in the MNE network was generally absent, we lack a complete understanding on the economic returns of subsidiaries different types of R&D efforts in local environments that are either distant or close to the global R&D frontier.

The aim of the present study is to fill these gaps by examining the individual and complementarity effects on subsidiary's productivity of subsidiary local R&D and R&D conducted in the MNE, contingent on the position of the subsidiary's host country with respect to the global R&D frontier of the industry. We utilize fine-grained data on R&D activities conducted by the MNE group specifically for the subsidiary (and financed by the subsidiary). We analyze productivity growth on a large panel of 3834 foreign subsidiaries based in the Netherlands and active in multiple industries in the period 1995 to 2003. The data are collected from an official survey conducted yearly by the Central Bureau of Statistics (CBS) in the Netherlands on R&D expenditures and value-added creation at the firm-level. We derive a dynamic panel model of productivity growth from an augmented knowledge production function where subsidiary knowledge is a function of subsidiary local R&D and R&D conducted for the subsidiary by the MNE network. We use System General Methods of Moments (GMM-SYS) to take into account possible endogeneity and productivity convergence between subsidiaries over time. We find that the relative intensity of R&D activities present in the local industry environment affects the returns to subsidiaries local R&D and its complementarity with R&D undertaken in the MNE network.

The remainder of this paper is as follows. Section 2 discusses the literature on foreign subsidiaries productivity, subsidiary local R&D and the complementarity effect with R&D in the MNE network and derives the hypotheses. Section 3 introduces the empirical base for the analysis, presents the augmented productivity model in condensed form and derives the equation to be estimated. In the final section, the results of the analysis are discussed and conclusions for further research are drawn.

3.2 Background

Traditional strategic management and international business theories link the expansion and success of MNEs into new geographic markets to the possession of specific 'ownership advantages' which give MNEs a competitive edge over local rival firms (Hymer, 1976; Caves, 1996, Grant, 1996; Teece, 1977; Buckley Casson, 1976, Dunning, 1993). According to the knowledge-based view of the firm, knowledge that is rare, valuable and difficult to imitate is central to the formation of these competitive advantages (Barney, 1991; Grant, 1996). Firms accumulate knowledge, especially technological knowledge, by investing resources into R&D activities. Through R&D efforts firms developed intangible proprietary assets in the form of new products, improved production processes and acquired technical expertise.

Among all MNEs' value-chain activities, R&D remains the last to be internationalized (Belderbos et al 2013; Berry, 2014) with most of R&D activities still conducted in the home country of the firm (Belderbos, et al., 2013; UNCTAD, 2004). Firms tends to maintain R&D centralized to maximize economies of scale and scope that characterize technology production at the firm level (Hewitt, 1980; Belderbos, et al., 2013), while minimizing the risk of knowledge leakages to foreign competitors (Alcacer & Zhao, 2012; Shaver & Flyer, 2000; Singh, 2007).

Therefore, the way MNE generated value from knowledge has been conventionally viewed as a unidirectional process: home base R&D was creating the knowledge assets that were then transferred to foreign subsidiaries and exploited in new geographic markets (Buckley & Casson, 1976). Following this view, the performance of foreign operations was ultimately dependent on knowledge developed at home. By successfully acquiring parent firm knowledge-based competitive advantages, newly established subsidiaries were able to overcome potential liabilities of foreignness occurring from operating a business in a new and unfamiliar environment (Zhaeer, 1995). Empirical research has shown that foreign owned firms are more productive (Arnold & Javorcik, 2005; De Backer & Sleuwaegen, 2003) and more innovative (Guadalupe et al., 2012; Sadowski et al, 2006; Un, 2011) than domestic firms.

In the last two decades, however, knowledge has become increasingly global: technological specialized clusters and centers of excellence have emerged around the world across multiple industries (Furman, et al., 2002). Consequently, the persistence of home country technological dominance is not likely to be valid for most of the firms (Doz & Santos, 1997). Knowledge-based competences and expertise drawn exclusively from home base clusters may no longer be sufficient to sustain the competitive advantage of MNEs foreign operations in technologically advanced countries. For this reason R&D internationalization patterns have started to change. Although a great part of R&D remains close to the headquarters (Belderbos et al., 2013), more attention has been given to the increasing share of R&D activities conducted by subsidiaries in their local markets (Odagiri & Yasuda, 1996; Kuemmerle, 1999; Alkemade et al., 2015).

Extant literature has provided abundant evidence of subsidiaries investing in R&D to source local know-how (Cantwell Janne, 1999; Cantwell & Piscitello, 2000; Singh, 2007; Song & Shin, 2008; Iwasa & Odagiri, 2004; Florida, 1997; Belderbos, 2003; Berry, 2006; Cantwell & Mudambi, 2005). Subsidiaries with R&D facilities in countries at the technological forefront are expected to stay competitive by innovating from the pool of specialized knowledge accessible locally. This type of subsidiary R&D is also named 'home-based augmenting' as it

expands the existing home base capabilities of the firm (Kuemmerle, 1999). In this case the conventional process of MNE's value creation from knowledge is inverted as parent firms are able to improve processes and develop new products by sourcing knowledge originated overseas via 'reverse knowledge transfer' (Ambos et al., 2006; Zhou & Frost, 2003; Hakanson & Nobel, 2000; Belderbos et al., 2015; Driffield et al., 2016).

MNEs can use subsidiaries R&D facilities to tap into localized pockets of expertise and learn cutting-edge technologies to integrate and recombine in their innovation processes (Bartlett & Ghoshal, 1989; Kogut & Zander, 1993; Hedlung, 1994). Thus, knowledge circulates within headquarter and subsidiaries MNE network. Subsidiaries can access and share knowledge not just vertically with the parent firm, but also horizontally with other subsidiaries. The entire MNE network might benefit from transfers of expertise developed locally by subsidiaries situated close to global centers of excellence (Zhou & Frost, 2003; Hakanson & Nobel, 2000).

At the same time, subsidiaries located in countries that are lagging behind the frontier of innovation might still find value in accessing knowledge from the MNE network as they have scarce opportunities for local knowledge sourcing. Hence, those subsidiaries will continue to source the MNE technical expertise and products to increase their competitive advantages in the local markets. However, knowledge assets held by parent firm and other subsidiaries embody a tacit and uncodified knowledge component that is difficult to transfer across the firm. The cross-border exchange of tacit knowledge requires frequent face to face interactions, multiple communication channels and the active involvement of both sender and receiver (Szulanki, 1996; Lane et al., 2001; Gupta & Govindarajan, 2000; Teece, 1977). A receiver with better capabilities facilitates the overall transfer process and is able to leverage more efficiently the knowledge acquired at the sender's location. In this sense, subsidiaries can invest in domestic R&D activities to improve their capacity to understand and assimilate knowledge from the MNE network and apply it to their local markets (Cohen & Levinthal, 1990). This may generate a complementarity between subsidiary domestic R&D and MNE R&D: the positive influence of MNE's R&D on subsidiary's performance is expected to increase with the R&D activities conducted by the subsidiary (Belderbos et al., 2008).

Most of the literature agrees that geographic dispersion of R&D can increase the overall firm's economic (Griffith et al., 2006; Kafouros et al., 2012) and innovative performance (Lahiri, 2010; Singh, 2008; Rahko, 2015; Criscuolo et al 2010). While prior studies have investigated the effect of foreign R&D on parent firm's efficiency (Belderbos et al. 2015; Todo &

Shimizutani, 2008; Fors, 1997) and its complementary with domestic innovation (Belderbos et al. 2015; Todo & Shimizutani, 2008; Penner-Hahn & Shaver, 2005), depending on the technological opportunities present at home (Belderbos et al., 2015) and the type of R&D performed overseas (Todo & Shimizutani, 2008). Understanding the joint contributions of subsidiary R&D and R&D in the MNE network on subsidiary economic performance is still scarce.

The literature on subsidiary innovation has used patent data to measure the effect of subsidiary's local environment and the MNE network technological strength on subsidiary's innovation output (Almeida & Phene, 2004; Phene & Almeida, 2008). Another stream of research on Japanese overseas subsidiaries has provided evidence for the positive influence of parent firm's R&D on subsidiaries' short and long term profitability (Delios and Beamish, 2001; Fang et al 2013; Fang et al , 2007; Fang et 2010), moderated by international and host country experience (Delios & Beamish, 2001; Fang, et al., 2007), the engagement of parent firm's expatriates in subsidiaries operations (Fang, et al., 2010) and the relatedness of home and host country markets (Fang, et al., 2013). Because of lack of more complete information at the subsidiary level, however, these studies fail to account for the innovative efforts undertaken by subsidiaries in their domestic markets and the amount of MNE knowledge assets they actively sourced.

Among the few studies that take those aspects into consideration (Belderbos et al 2008; Contractor et al, 2016; Fors, 1997; Berry, 2015), Belderbos et al. (2008) and Fors (1997) found parent firm R&D investments and parent firm knowledge transfers to improve subsidiaries' value added productivity in subsidiaries of Japanese (Bederbos et al., 2008) and Swedish (Fors, 1995) firms after controlling for subsidiary R&D. Belderbos et al. (2008) also found a complementarity effect between parent firm technology transfers and subsidiary R&D. They did not consider, however, differences in the technological opportunities present in the subsidiaries local environments

Berry (2015) addresses some of these differences in a recent study on the impact of parent firm technological and managerial knowledge on the financial performance of US subsidiaries. The author considers the industry technological position of US and subsidiary host country and finds that parent firm technological transfers are relevant only if US is the global technological leader in the industry, while subsidiary local R&D is more important for subsidiaries located in technologically dominant countries. Yet, the study does explore only complementarities between parent firm managerial knowledge transfer and subsidiary local R&D efforts without

saying much on pure technological interdependences and synergies between R&D activities carried at the MNE network and at the subsidiary .

In this paper, we advance arguments for the joint effects on subsidiary productivity of subsidiary local R&D and R&D conducted specifically for the subsidiary by parent firm and other subsidiaries part of the MNE network. Productivity reflects the value generate with the efficient use of a given quantity of capital and labor inputs. Improvements in the efficient transformation of inputs into output are considered a direct function of technological change and knowledge creation, which are obtained, in turn, by investing in R&D activities (Hall et al., 2012). Therefore, productivity can be considered an appropriate measure to capture the performance effect of the distribution of R&D between subsidiary and the rest of the firm (Griffith et al., 2006; Driffield & Love, 2007; Winston-Smith, 2014; Belderbos et al., 2015). Both R&D costs reduction effects from process innovation and turnover growth effects from new products developments enter the productivity calculation.

3.3 Hypotheses

Technological development is widely understood as a cumulative process highly dependent on the specific geographic context. Strands of innovation tend to originate and grow within a limited geographic area that permits complex knowledge and ideas to be transmitted and shared in the local scientific community via frequent face-to-face interactions (Saxenian, 1994; Audretsch & Feldman, 1996). As knowledge spillovers remain to a large extent geographically bounded (Jaffe et al., 1993; Singh, 2005), innovation activities are likely to concentrate in regional technological clusters and benefit from agglomeration economies (Porter, 1990). With the rise of globalization and the increased competition among countries, national innovation systems invest their resources in sectors where they already possess a ‘comparative advantage’. The cumulative nature of technology follows a ‘path-dependence’ behavior that fosters further spatial technological specialization (Cantwell & Jane, 1999; Arthur, 1989). Depending on their pre-existing knowledge base, countries form specific technology profiles and become leaders in different industries. Technological gaps between countries tend to persist also because of differences in their innovation productivity due to socio-economic factors such as the education system, innovation public policies, the infrastructure system and market structure (Furman et al., 2002).

In national innovation systems at the global frontier, MNE might struggle to compete with local technology-leading firms. In this case, the tacit knowledge held by local actors is necessary for the MNE to keep up with industry technological advances and develop a product offer that satisfies sophisticated and highly demanding local costumers. MNEs are expected to create more value by intercepting and absorbing localized external spillovers via local R&D investments rather than learning home-based outdated technologies (Singh, 2007; Song & Shin, 2008; Iwasa & Odagiri, 2004). Literature on location choice have confirmed that MNEs establish their R&D lab in regions with technological comparative advantages (Chung & Alcacer, 2002; Chung & Yeaple, 2008). Numerous studies on knowledge flows using patent citations have provided evidence of subsidiaries local knowledge sourcing. Almeida (1996) showed that U.S. subsidiaries of foreign MNEs active in the semiconductor sector source from regional local knowledge even more than U.S. firms located in the same region. In another important study, Frost (2001) explored the geographic sources of subsidiary's innovation and found that subsidiaries are more likely to source knowledge from the host country rather than the home country if the latter possesses a technological advantage in the field of the subsidiary. Finally, Phene and Almeida (2008) found that knowledge assimilated from host country firms increases foreign subsidiaries quantity and quality innovation output.

There are several ways through which subsidiaries can source local tacit knowledge to increase their competitive advantage. Subsidiaries in technologically advanced countries can develop specific competences directly from working in close contact with local highly productive suppliers or by meeting the particular demands of customers in the region. They can establish scientific collaborations with local universities, start joint R&D projects with indigenous firms or hire local specialized engineers to work in their facilities (Griffith et al, 2006; Criscuolo & Autio, 2008; Almeida & Kogut, 1999; Lewin et al., 2009). These actions require subsidiaries to invest resources into local innovative activities rather than accessing knowledge developed elsewhere in the MNE network. Strong internal capabilities derived from local R&D activities are expected to strengthen further the subsidiary's capacity to integrate in the local scientific community and learn from global technology leaders present locally (Song et al., 2011; Cantwell & Mudambi, 2005).

Opposed to that, when the local innovation system does not offer subsidiaries valuable opportunities to expand their capabilities and become more efficient, subsidiaries can turn to the headquarter and other subsidiaries that form their internal MNE network (Almeida and Phene, 2004). The MNE superior managerial and coordination capabilities and the built-in trust

within the group allow subsidiaries to source knowledge possessed by the MNE in other countries that would be otherwise too difficult or costly to acquire (Bartlett & Ghoshal, 1989; Kogut & Zander, 1993; Hedlung, 1994). Competences and expertise assimilated by the MNE in countries that dominate the global industry technology can help the subsidiaries to develop new products and processes that outcompete the ones available to local competitors. Intra-firm cross-border exchange of knowledge explains a substantial part of the performance gap between domestic and multinational firms (Criscuolo et al., 2009).

Based on the above discussion, the different effects that subsidiaries local R&D and acquired R&D from their MNE network will have on subsidiaries performance will ultimately depend on the relative innovative position of their host country. R&D performed locally is likely to be more important for the productivity of subsidiaries located in leading countries at the R&D frontier. On the other side, if the country of the subsidiary is lagging behind the frontier, the subsidiary is likely to derive more productivity improvements from accessing foreign R&D activities conducted in the rest of the MNE network. Therefore, we expect the following:

Hypothesis 1. Subsidiary local R&D is more effective in improving subsidiary productivity in host countries that are at the industry global R&D frontier, while R&D conducted by the MNE for the subsidiary is more effective in improving subsidiary productivity in host countries that are behind the industry global R&D frontier.

So far we have suggested that subsidiaries located in countries with relatively less technological opportunities would find effective to source cutting-edge knowledge from other leading countries through their parent firm and other subsidiaries part of their MNE network. However, the complex and advanced expertise acquired from the MNE network has to be decoded, absorbed and translated into improvements of subsidiary operations and products to become beneficial to the subsidiary. Most of the time additional developments and adaptations are required in order to apply foreign technology to the specific characteristics of the local market (Vernon, 1969; Kummerle, 1997). Subsidiaries might need to invest in upgrading their machinery and adapt the production process considering the resources available in the area.

Local R&D facilities can help subsidiary on these tasks. Subsidiary's 'home-based exploiting' R&D (Kummerle, 1997) has the main function to support foreign manufacturing activities in the exploitation and local improvement of technologies already possessed by the MNE. Hence, through local R&D, subsidiaries increase their absorptive capacity to assimilate foreign knowledge and maximize its productivity-enhancing effect. In line with this, Un and Cuervo-

Cazurra (2008) showed that foreign owned Spanish firms have the same level of internal R&D than domestic Spanish firms despite having access to external technologies from their MNE network.

Additionally, the simultaneous engagement in local and international R&D projects increase economies of scope and the potential for cross-fertilization and knowledge recombination. The discovery of new applications for ideas developed in different contexts can increase the returns to related R&D domestic projects. Extant literature has provided ample evidence of complementarities between firm internal and external R&D (Cassiman & Veugelers, 2006; Lokshin et al., 2008), different R&D cooperation strategies (Belderbos et al., 2006) and domestic and international technology transfers (Belderbos et al., 2012). Bertrand and Capron (2015) investigated the effect of cross-border acquisitions on domestic productivity of French firms. The authors fund positive domestic productivity gains from cross-border acquisitions of target firms located in more competitive countries. The gains from the acquisitions were larger for those firms that underwent contemporaneous productivity-enhancing domestic investments. In another study on Dutch parent firms, Belderbos et al. (2015) found that in industries with relatively more opportunities of international knowledge sourcing, domestic R&D increases the effectiveness of reverse knowledge transfer from foreign R&D on parent firm productivity.

Along these lines, we expect positive complementarities between subsidiary local R&D and R&D in the MNE network (Belderbos et al., 2008). However, we expect to find complementarities only when the environment does not provide the subsidiary with enough opportunities to acquire leading expertise and know-how locally. In these circumstances, there is higher potential in accessing advanced knowledge from other countries through the R&D conducted at the parent firm or in other subsidiaries part of the MNE network. Yet, the R&D from the MNE network is not expected to completely cancel the impact of subsidiary local R&D efforts. Subsidiaries will still find local R&D decisive to absorb the new MNE expertise. Subsidiaries R&D is likely to strengthen the effective knowledge sourcing from the MNE network. Consequently, the marginal returns of MNE R&D on subsidiary productivity are likely to increase with subsidiaries local R&D. Likewise, the new capabilities accumulated from the MNE knowledge sourcing are likely to have a positive effect on the R&D projects undertaken domestically, thus increasing also the marginal returns on local R&D.

By contrast, for subsidiaries in countries that produce the leading technologies in the industry, the opportunities to find valuable knowledge in the rest of the MNE network located in other

countries are relatively scarce. In these circumstances, complementarities between subsidiary local R&D and R&D in the MNE network are likely to be weaker. Subsidiaries local R&D is expected to be mostly devoted to learn cutting-edge know-how developed locally, rather than absorbing MNE technologies that will bring no substantial competitive advantage to the subsidiary in its market. Finally, as the rest of the MNE network is likely to be located in national innovation systems that are lagging behind the subsidiary host country, their expertise is not expected to induce strong improvements in the local technological search of the subsidiary. Hence, the marginal returns of subsidiary local R&D will depend less on R&D performed for the subsidiary in the rest of the MNE network. Therefore, we expect the following:

Hypothesis 2. Subsidiary local R&D and R&D conducted by the MNE for the subsidiary have a stronger complementary effect on subsidiary productivity in host countries that are behind the industry global R&D frontier.

3.4 Model derivation and econometric estimation

We build on Lokshin et al. (2008) to construct a model of labor productivity growth as a function of subsidiary local R&D and R&D accessed by the subsidiary from parent firm and other subsidiaries part of its MNE network, MNE R&D. The model is derived from an augmented Cobb-Douglas production function for subsidiary *i* at time *t* with knowledge stock as an input:

$$Y_{it} = \alpha_i L_{it}^{\beta} C_{it}^{\delta} K_{it}^{\gamma} e^{\sigma_{it}} \qquad (1)$$

where Y is value added of subsidiary *i* in time *t*, L is the labor input, C is the physical capital stock and K is the knowledge stock. β, δ, and γ are elasticities with respect to labor, physical capital, and the knowledge stock. The parameter σ_{it} is a time-variant and subsidiary-specific efficiency parameter. Dividing both sides by labor, taking log and differencing the resulting equation in two consecutive periods, we obtain the equation in the growth form:

$$\Delta q_{it} = (\beta - 1)\Delta l_{it} + \delta \Delta c_{it} + \gamma \Delta k_{it} + \Delta \sigma_{it} \qquad (2)$$

where $q_{it} = log(Y_{it}) - log(L_{it})$ denotes labor productivity, $\Delta q_{it} = q_{it} - q_{it-1}$ is the proportional growth in labor productivity, with lower-case letters denoting variables in natural logarithms.

In equation (2) time-invariant subsidiary effects are canceled out from$\Delta\sigma_{it}$, but we model the change in subsidiary-specific efficiency levels as a function of past productivity:

$$\Delta\sigma_{it} = \theta q_{it-1} + \varepsilon_{it} \qquad (3)$$

This allows for a gradual convergence between subsidiaries in efficiency levels, with less efficient subsidiaries more likely to fill the productivity gap faster via spillovers from more efficient subsidiaries. This mechanism has been considered important in the empirical literature on firm productivity (Klette, 1996; Bundell & Bond, 2000; Lokshin et al., 2008). We expect θ to fall within the interval [-1, 0]. With θ equal to zero there is no gradual convergence between less productive subsidiaries and more productive subsidiaries; while θ equal –1, means complete convergence in one period. The error term ε_{it} in equation (3) includes a year-specific intercepts λ_t to account for macroeconomic shocks on productivity and a serially uncorrelated component v_{it} for measurement errors and unobserved subsidiary-level heterogeneity:

$$\varepsilon_{it} = \lambda_t + v_{it} \qquad \text{for} \quad i = 1,\ldots, N;\ t = 1,\ldots, T \qquad (4)$$

We can transform the knowledge stock portion of the specification (cf. Griffith, et al., 2004, p.7; Jones, 2002, p. 233) as follows:

$$\gamma\Delta k_{it} \approx \frac{\partial Y}{\partial K}\frac{K_{i,t-1}}{Y_{i,t-1}}\frac{\Delta K_{it}}{K_{i,t-1}} \approx \varphi\frac{\Delta K_{it}}{Y_{i,t-1}} \qquad with\ \varphi = \frac{\partial Y}{\partial K} \qquad (5)$$

with φ the marginal return to knowledge from R&D. The assumed change in the R&D stock is a function of subsidiary's investments in both local and MNE R&D:

$$\Delta K_{it} / Y_{i,t-1} = f(R^{loc}_{it-1} / Y_{i,t-1}, R^{MNE}_{i,t-1} / Y_{i,t-1}) = f(r^{loc}_{i,t-1}, r^{MNE}_{i,t-1}) \qquad ` \quad (6)$$

We approximate the unknown function (6) with a reduced second-order polynomial in R&D investments. Assuming a small depreciation rate of the knowledge stock[15], we can write:

$$\gamma\Delta k_{it} = \varphi[\eta_1 r^{loc}_{i,t-1} + \eta_2 r^{MNE}_{i,t-1} + \eta_3 (r^{loc}_{i,t-1})^2 + \eta_4 (r^{MNE}_{i,t-1})^2 + \eta_5 r^{loc}_{i,t-1} r^{MNE}_{i,t-1}] \qquad (7)$$

[15] Higher depreciation rates lead to an upward bias of the estimate on the rate of return (Mairesse & Sassenou, 1991). We could extend the approximation of the knowledge stock changes to the lags of R&D. Though, previous studies indicate that most of the R&D effect on productivity occurs within one year (Pakes & Schankerman, 1984; Hall et al., 1986; Klette & Johanson, 1998).

The equation includes linear and quadratic terms of local and MNE R&D and the interaction between the two linear terms. The quadratic terms allow for potential (dis)economies of scale and scope in R&D investments which have been found in earlier studies especially in large firms with heavy R&D pockets (Acs & Isberg, 1991; Cohen & Klepper, 1996). Furthermore, the inclusion of a quadratic term is important to avoid that possible non-linarites contaminate the complementarity effect between local and MNE R&D that we want to test with the interaction term. Additionally, we must note that a full polynomial expansion would include also interactions between the quadratic the linear terms as well as the interaction between quadratic terms. However, the high correlation between high order terms would make the identification of each effect extremely challenging.

As capital investments are not available for a sufficiently long period we are not able to compute the capital stock variable using the perpetual inventory method. As an alternative, we use the log-growth in fixed capital investment to approximate for the log-growth in the capital stock Δc_{it}. In steady state, the proportional change in the capital stock can be approximated by the proportional change in fixed capital investments (Jones, 2002).

Combining equations (2), (3), and (7) and bringing the lagged productivity term to the right-hand side, we arrive at the dynamic panel equation:

$$q_{it} = (1+\theta)q_{it-1} + (\beta - 1)\Delta l_{it} + \delta \Delta c_{it} + \varphi[\eta_1 r_{i,t-1}^{loc} + \eta_2 r_{i,t-1}^{MNE} + \eta_3 (r_{i,t-1}^{loc})^2 + \eta_4 (r_{i,t-1}^{MNE})^2 + \eta_5 r_{i,t-1}^{loc} r_{i,t-1}^{MNE}] + \lambda_t + \nu_{it} \quad (8)$$

The estimation of production functions equations present several econometric issues (Van Beveren, 2012). The choice of (freely variable) inputs, such as R&D investments, might be endogenous to unobserved subsidiary heterogeneity. The R&D coefficients might be correlated with past productivity shocks and omitted subsidiary characteristics, such as good R&D managers or highly skilled workforce. For instance, positive shocks in productivity could induce the subsidiary to increase its output and to invest more in local R&D activities as their expected benefit would be higher. In the current model, however, we use lagged values of R&D, which should not be correlated with the current error term. Nevertheless, the R&D variable can still be correlated with past productivity shocks for the same logic explained above, and with individual unobserved subsidiary effects. The dynamic structure of the model does take this potential endogeneity into account as lagged productivity is included in the right hand side variables. Since the R&D variables are not strictly exogenous and the lagged dependent variable

is correlated with the current error term by construction, the model cannot be estimated consistently with neither OLS[16] nor fixed effects (Bond et al., 2001).

We handle this by estimating equation (8) with the System-GMM dynamic panel model proposed by Arellano & Bond (1991). By making certain assumptions over the initial conditions[17], we can use lagged first differences and lagged levels of the right-hand side variables as valid instruments for our right-hand side variables. System GMM estimates a system of equations that includes a level equation, where level variables are instrumented with their lagged first differences, and a first differenced equation, where the instruments used are the lagged level values[18]. In the level equation year and industry dummies are included. In the first differenced equation subsidiary specific constant term, individual time-invariant effect, cancels out. This technique has the advantage to provide consistent estimates in dynamic panel samples with a large number of units and a short time period, as in our case.

3.5 Data

The data on which the model is estimated are drawn from the Dutch Central Bureau of Statistic (CBS) annual R&D surveys and additional production and financial statistics on firms operating in the Netherlands compiled by the same office. Information on firm' R&D expenditures and their breakdown are obtained from the R&D surveys conducted yearly on a stratified sample of all Dutch firms listed in the General Business Register with more than 10 employees. The CBS provides official figures for the total R&D expenditures in the Netherlands that are used by Eurostat and the OECD. We then merge the R&D survey data with the firm level production database to obtain firm's value added, number of employees, fixed capital investments as well as industry specific output deflators. For the purpose of our research, we remove from the sample all firms that are not foreign owned, so we focus the analysis only on foreign subsidiaries.

[16] In an unreported trial we also try to estimate the model with simple OLS but we did not obtain sensible results. However, in dynamic models, as the one used in this chapter, the lagged dependent variable regressor is, by construction, correlated with the current error term (Bond et al., 2001). In this case, the OLS estimator is inconsistent and it gives an upward biased coefficient of the lagged dependent variable. Therefore, the GMM model remains the preferred choice in the current study.

[17] It is necessary to assume no serial correlation of the productivity shocks and no correlation between the dependent variable first differences and the time invariant unobserved effect.

[18] Starting from two period lagged for productivity and R&D variables and one period lagged for employment and capital growth.

Each merged database covers a wide array of foreign subsidiaries in terms of size, R&D intensity and industries spectrum. We collect data from 1995 to 2003, but since smaller firms are randomly sampled in each year, we are not able to track every subsidiary throughout the entire period. That leaves us with an unbalanced panel where subsidiaries are observed on average for four consecutive years. This number reduces to two in the final dataset as we employ a dynamic econometric specification with lagged periods used as instruments for the GMM estimation. The final sample is composed of 3834 observations on 1756 foreign subsidiaries between 1995 and 2003.

We construct our dependent variable, labor productivity, as net value added per employee at constant prices. Management literature has started to pay more attention to productivity as a measure of performance (Bertrand & Capron, 2015). Productivity metrics indicates the efficiency with which a firm is able to transform its inputs (capital and labor) into outputs. It considers the full value generated by the firm before it gets distributed over all its stakeholders that include shareholders, but also employees and managers. Therefore, productivity represents the operational effects of firm's product and process technology more comprehensively and directly than other performance measures such as market value or accounting profits, which only maximize shareholders benefits and may also capture value from other firm's financial operations and tax incentives. Productivity, as a performance measure, captures both the cost reducing effects of R&D and innovation efforts and the effects of new product development on price-cost margins and it is comparable across industries and countries.

Subsidiary's R&D is divided between R&D expenditures on R&D activities undertaken by the subsidiary in the Netherlands, *local R&D*, and R&D expenditures on R&D contracted outside the Netherlands with the parent firm or other subsidiaries part of the MNE network, *MNE R&D*. The latter represents R&D activities being conducted by the MNE specifically for the subsidiary which ultimately finances them. Both R&D expenditures enter the model as ratios of value added. Other variables included in the model are growth in the capital stock to be approximated by the growth in fixed capital investments, and employment growth that is the growth in the number of employees (expressed in full time equivalents). Value added, fixed capital investment and R&D expenditures are transformed in constant prices using industry-specific deflators. The models include 9 year dummies and 28 Industry dummies.

We investigate possible differential effects of local and MNE R&D dependent on how far is the local industry from the global R&D frontier by looking at the industry-level R&D intensities

(the ratio of R&D to value added in constant prices) reported every year in the Netherlands compared to other OECD countries. More specifically, we identify a leading (lagging) industry if the industry R&D intensity in the Netherlands falls within (below) the OECD countries top quartile. This approach is similar to the one used by Griffith et al. (2006) and Salomon and Jin (2008) and is based on the idea that the higher is the intensity of industry R&D activities present in the environment, the more subsidiary R&D can benefit from knowledge sourcing and spillovers[19]. We report information on R&D, and leader and laggard status per industry in Table A1 in the Appendix. Most industries do not change their position with respect to the global R&D frontier over the study period, highlighting the relative stability of country innovation system worldwide.

We test potential differential effects of local and MNE R&D contingent on the technological opportunities in the local industry by means of a split sample analysis. We run two separate models for the subsamples of subsidiaries operating in leading vs lagging industries. Split sample analysis allows to test for differences in the effects of R&D types as R&D coefficients, together with the others, are allowed to vary between leading and lagging industries (Hoetker, 2007; Belderbos & Zou, 2009). We must notice, however, that factors elasticities are implicitly assumed to be equal across industries that belong to the same subsample. This assumption is necessary to identify the R&D productivity effect of being in an environment with high (or low) knowledge opportunities. As differences in knowledge opportunities are constructed at the industry level, estimations of industry specific production functions would assimilate that effect in the industry specific R&D coefficient. Moreover, most of the industries in the sample contain a number of observations not sufficient to estimate in a consistent way our non-linear GMM

[19]We note that R&D is an input measure of innovation, so the final knowledge opportunities present in the country may still be influenced by how well spent and effective the R&D is. An alternative approach would be to construct a measure of technological frontier starting from patents (innovation output) invented in the country. In an unreported trial, we retrieved all international patents (PCT) and assigned them to OECD countries based on their inventors' addresses provided in the OECD REGPAT database. We used the concordance table developed by Van Looy et al. (2015) to match patent technology classes (IPC) with NACE 2digits industries and obtain a measure of industry patent intensity. Unfortunately several industries of the sample proved to have a low propensity to patent which resulted in very unstable series of patent intensities, especially for small countries such as the Netherlands. We were not able to obtain a satisfying level of overlap with the spilt samples from the original measure of R&D frontier as the patent based measure presented severe fluctuations. Further research should try to tackle these practical challenges in order to obtain a better measure of global frontier based on the innovation outputs generated in the local environment.

model as that requires a large number of N to construct reliable instruments for our endogenous variables[20].

3.6 Results

Table 1 reports the descriptive statistics of the variables used in the estimation for each subsample together with their pairwise correlations.

Table 3-1 Variable construction, descriptive and correlations (No. obs. = 3564)

	Variable	Mean	s.d.	1	2	3	4	5
	Lagging industries(N=2049)							
1	Productivity	4.075	0.55					
2	Productivity t-1	4.066	0.51	1				
3	Δ Labor	0.010	0.22	0.78	1			
4	Δ Investment	0.037	0.42	-0.09	0.05	1		
5	R&D Local[a]	0.092	0.13	0.07	-0.07	0.26	1	
6	R&D MNE[b]	0.0041	0.01	-0.06	-0.11	0.00	0.01	1
	Leading industries(N=1515)							
1	Productivity	4.080	0.57					
2	Productivity t-1	4.071	0.52	1				
3	Δ Labor	0.005	0.24	0.75	1			
4	Δ Investment	0.029	0.47	-0.11	0.04	1		
5	R&D local	0.115	0.17	0.12	-0.12	0.29	1	
6	R&D MNE	0.0038	0.01	-0.07	-0.13	-0.04	0.05	1

[a]Independent sample t-test on the difference in means of R&D local between lagging and leading industries is statistically significant at the 1% level.

[b]Independent sample t-test on the difference in means of R&D MNE between lagging and leading industries is not statistically significant.

Subsidiaries report almost equal productivity in the two groups, while lagging subsidiaries have higher growth rates of capital investment. Nevertheless, labor productivity averages might be difficult to compare since leading and lagging industries might be systematically different for the Netherlands in terms of capital intensity. As a first descriptive evidence, we note that subsidiaries' local R&D intensity is higher in leading industries, while the intensity of R&D activities conducted for the subsidiary by the MNE is higher in lagging industries. However,

[20] Most of existing literature that use GMM econometric model to estimate R&D returns in a production function framework assume equal factors elasticities across industries (Belderbos & Lokshin, 2015; Griffith et al., 2006; Bond et al., 2003; Capron & Cincera, 1998).

the independent sample t-test on the difference in means rejects equality only for local R&D (at 1%). Finally, correlation levels do not seem to indicate multicollinearity.

Table 2 reports the results for the GMM estimation of equation (8). Model 1 includes all foreign subsidiaries, Model 2 only the subsample of subsidiaries active in lagging industries behind the global R&D frontier and Model 3 the remaining subsample of subsidiaries in leading industries. The exogeneity of the instruments cannot be rejected by the Hansen test statistic for overidentification, this is an indication of the validity of the instruments.

Table 3-2 GMM regression analysis of Foreign Subsidiaries' Performance

VARIABLES	Full sample Model 1	Lagging industries Model 2	Leading industries Model 3
Productivity t-1	0.654***	0.574***	0.734***
	(0.036)	(0.047)	(0.050)
Δ Labor	-0.444***	-0.413***	-0.511***
	(0.025)	(0.032)	(0.039)
Δ Capital stock	0.224***	0.149***	0.308***
	(0.013)	(0.017)	(0.021)
R&D local	0.309***	0.153	0.381***
	(0.102)	(0.133)	(0.109)
R&D2 local	-0.029**	0.019	-0.046***
	(0.015)	(0.026)	(0.015)
R&D MNE	1.215***	1.910***	-0.327
	(0.379)	(0.724)	(1.403)
R&D2 MNE	-1.775**	-4.960***	1.338
	(0.728)	(1.742)	(2.880)
R&D local x R&D MNE	0.395**	1.177***	0.426
	(0.198)	(0.450)	(0.300)
Observations	3,564	2,049	1,515
Number of firmid	1,751	1,018	849
Chi2	2799	2451	838.1
Hansen test (d.f.)	84.0 (72)	72.1 (72)	85.9 (72)
p-value	0.157	0.475	0.126
AR1	-10.92	-7.112	-7.807
AR1 p-value	0	0	0
AR2	-0.101	-1.198	-0.199
AR2 p-value	0.920	0.231	0.842

One-step GMM standard errors in parentheses. The regressions contain year dummies, the level equations contain industry dummies *,**,*** indicate 10, 5 and 1 percent levels.

The past labor productivity has an estimated coefficient of 0.65 in the full model. This suggests that approximately one third (0.66-1) of productivity advantage is offset within one period via convergence. We see a stronger persistence in productivity differences for leading industries (-0.27) compared to lagging industries (-0.42). Employment and capital investments growths are

significant at 1% level with elasticities respectively of 0.56 (1-0.44) for labor and 0.22 for capital, consistent with values found in prior studies with similar production function specifications (Fors, 1997; Belderbos et al., 2015). Labor elasticity is relatively higher for lagging subsidiaries, while productivity growth is more elastic to capital growth in leading industries.

Regarding subsidiary R&D activities, model 1 suggests a significant inverted U shape relationship with productivity growth of both, local and MNE R&D. The marginally significant interaction term also indicates a positive complementarity between the two R&D expenditures. However, when we look at the two subsamples the picture becomes more complex: the linear and quadratic terms of local R&D are statistically significant only for subsidiaries in industries at the global frontier, whereas in lagging industries only MNE R&D is significant. Hence, local R&D is more effective in improving subsidiaries' productivity in leading compared to lagging industries, while the opposite is true for R&D conducted for the subsidiary elsewhere in the MNE, thus confirming Hypothesis 1. Moreover, the positive and statistically significant interaction effect between local and MNE R&D in lagging subsidiaries, but not in leading industries, provides support for Hypothesis 2.

Following from equation (5) the coefficients of local and MNE R&D are not elasticities, but must to be interpreted as rate of returns to value added. Although the significant negative coefficient of the quadratic term suggests declining returns to local R&D in leading industries, the turning point, assuming no MNE R&D[21], is estimated at 4.14 which is well beyond the values of local R&D intensity observed in the sample. In lagging industries the marginal returns to MNE R&D start to turn negative at 0.19, also outside the range of observed values. The steeper curve of the MNE R&D suggests that there is a limit to the knowledge that can be coordinated and transferred across geographic distances, thus reducing the potential economies of scale of R&D conducted in other large facilities of the MNE.

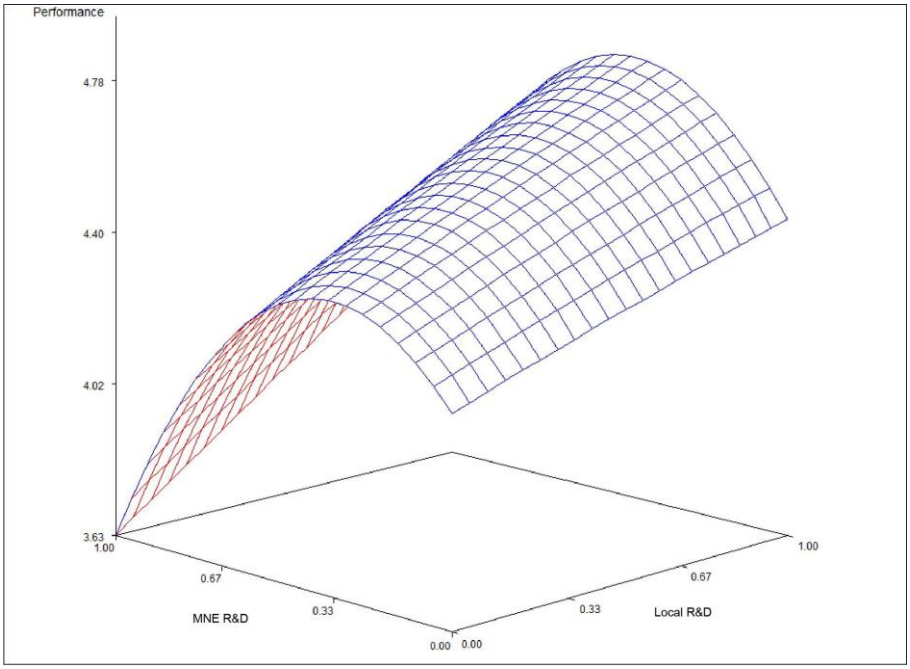
In leading industries, at small initial levels of local R&D, the linear coefficient displays a rate of return of local R&D to value added of 0.38, which implies that 100 euros invested in local R&D increase subsidiary's net value of added of 38 euros. This rate of return is in line with what found in prior studies with a similar production function specification (Lokshin et al., 2008; Mairesse & Sassenou, 1991). In lagging industries, however, the local R&D coefficients are not statistically different from zero, thus the results suggest that local R&D alone does not

[21] the correct formula to calculate the inflection point for local R&D is $r_{i,t-1}^{loc} = (\eta_2 + \eta_5 r_{i,t-1}^{MNE}) / -2\eta_4$

contribute to generate value added unless it complements R&D undertaken in the MNE network. In this subsample, MNE R&D has an estimated rate of return, for low levels of local and MNE R&D, of 1.91.

Figure 1 plots the combined total effect of local and MNE R&D on (the logarithm of) subsidiary labor productivity in lagging industries, taking into account the positive coefficient of the interaction term that strengthen the returns of the two R&D strategies. The other factors, capital and labor, are set at their sample means for the calculation. The surface of the graph illustrates that solutions with either of the two R&D expenditures set to zero are not optimal. Subsidiary productivity initial increase along the MNE R&D dimension is steeper if the curve is transposed on positive levels of local R&D. Thus, subsidiaries that already have access to a sufficient amount of knowledge from their MNE network can attain higher returns on productivity by combining it with local R&D activities. The graph also shows that further increases in MNE R&D intensity erodes labor productivity because of diseconomies of scale. However, it should be noted that the observed levels of MNE R&D intensity in lagging industries do not exceed 0.09.

Figure 3-1 Predicted effects of local and MNE R&D intensity on (the logarithm) of labor productivity in lagging industries



With a bit of algebra is also possible to calculate the optimal share of subsidiary R&D expenditures used for local R&D over total subsidiary R&D expenditure. Using the coefficients

estimated in Model 2 and setting local R&D at the sample mean we obtain an optimal share of MNE R&D of 67%[22] which is substantially greater than the average (4%) observed in the subsample of subsidiaries operating in industries behind the global frontier. This indicates potential room for productivity improvements that can be obtained by relying more on the R&D conducted abroad by the MNE group.

3.7 Supplementary analysis

To check the consistency of our results we perform a set of sensitivity tests reported in the Appendix. First, we experiment with a different threshold to define the industry global R&D frontier. We take industries in the last quartile of R&D intensity in OECD countries as the R&D frontier. Results reported in appendix Table A2 reach similar conclusions for the differential effects of local and MNE R&D and their complementarities across the two subgroups. Second, we substitute value added with gross output to construct the labor productivity of the subsidiaries. Normally, in the absence of data on material costs, as it is the case in the current study, the literature on R&D and productivity (Hall et al., 2010) suggests to use a value added specification. R&D expenditures are positively correlated with materials: a sales production function without including material costs could lead to upward biased coefficients of R&D expenditures (Griliches & Mairesse, 1984). Nevertheless, results in Table A3, using sales based productivity, provide similar conclusions. Third, we exclude from the analysis all service sectors which may different in factors elasticities and use of R&D to innovate. Table A4 shows consistent results with our main model. Finally, we observe that, in the main model, local R&D in subsidiaries active in lagging industries does not have a direct effect on productivity when MNE R&D is absent. This finding is difficult to reconcile with the fact that most of the observed subsidiary's R&D is reported locally. One potential explanation for the lack of a direct effect of local R&D could be the complex higher order functional form chosen to allow for R&D diseconomies of scale in the original model. That could make the identification of the effect of each R&D component difficult. In Table A5 we report the results of the alternative specification without the quadratic term for local R&D. This time the results show a positive and statistically significant coefficient for the linear term of local R&D as well as a significant complementarity effect with R&D conducted by the MNE. The estimates indicate for small initial levels of local R&D, and no MNE R&D, a rate of return on local R&D of 0.24, i.e. a value added increase of

[22] $r_{i,t-1}^{MNE} / (r_{i,t-1}^{MNE} + r_{i,t-1}^{loc}) = (\eta_2 + \eta_5 r_{i,t-1}^{loc}) / [\eta_2 + (\eta_5 - 2\eta_4) r_{i,t-1}^{loc}]$

24 cents for every euro invested in local R&D. As expected, this is still smaller than what initially found for subsidiaries in leading industries.

3.8 Conclusions

The present study examines the effect of both subsidiary local R&D and R&D conducted for the subsidiary in the MNE network on the productivity of 1756 foreign subsidiary located in the Netherlands. The results suggest that the two types of R&D investments have a different impact on subsidiary performance depending on the characteristics of the subsidiary local environment. When the host country provides abundant opportunities to source knowledge at the industry global forefront, the R&D conducted in the MNE network for the subsidiary does not have a notable effect on subsidiary performance. Instead, investments in local R&D activities are found to significantly improve subsidiaries productivity in those environments. R&D conducted by the MNE specifically for the subsidiary is relevant for its productivity only in situations where the host country is lagging behind the industry global R&D frontier. This study suggests that the traditional view that considers MNEs able to exploit their home based expertise in foreign markets (Buckley & Casson, 1976; Caves, 1996; Hymer, 1976) only applies for specific conditions of local knowledge scarcity. This combination, i.e. MNE's R&D conducted for subsidiaries in lagging industries, reports estimated rate of returns higher than what found for local R&D investments of subsidiaries in leading industries. Precisely, our model estimates that one euro invested in MNE R&D by subsidiaries located in industries behind the global R&D frontier generates almost two euros in value added, compared to 33 cents generated with one euro of local R&D invested by subsidiaries in leading industries. Nonetheless, the observed share of MNE R&D over total subsidiary R&D in these industries is still largely below the optimal share estimated by our model. The reasons why subsidiaries may not invest enough in MNE R&D can be multiple. Subsidiaries that were acquired by the MNE could be too locally oriented and thus less integrated with the MNE group than greenfield investments. Acquired subsidiaries might have less incentives and motivations to setting up R&D contracts with the MNE group that could imply extra costs and complexities than maintaining all the R&D locally. Moreover, subsidiaries might have a limited competence-creating mandate that focuses only on the development of technologies for the local market (Cantwell & Mudambi, 2005). These conditions block substantial productivity improvements that could derive from leveraging more systematically the innovative capabilities of the MNE group.

Our findings also suggest that, where the R&D environment is not strong, the positive returns to R&D conducted in the rest of the MNE network are greater if the subsidiary continues to invest resources in local R&D activities. Through local R&D, subsidiaries develop the capacity to fully process and apply more advanced MNE knowledge. This complementarity effect generates further productivity gains which would not have been attained solely by acquiring the R&D from the MNE network. We must also note that the model finds an appreciable effect of local R&D investments on subsidiary productivity in lagging industries only in combination with MNE R&D. Although in line with our theory that predicts a weaker role of local R&D in those environments, the result is at odd with the observed fact that local R&D represents the large part of subsidiary total R&D expenditures. In these circumstances, it is difficult to justify subsidiaries' economic decision to invest in local R&D only as a complement to R&D conducted elsewhere in the MNE group. However, we do find local R&D to improve subsidiaries productivity once we adopt a more linear specification of the model that does not include diminishing returns to local R&D expenditures.

Our study contributes to the literature on subsidiary productivity and R&D internationalization by showing the influence of the host country relative technological strength on the returns to subsidiary R&D investments in local R&D and in international R&D conducted inside the MNE group and their potential complementarities. Until now, subsidiary's host country position in the international technological landscape has been examined mostly in the context of MNE's international knowledge flows (Song & Shin, 2008; Cantwell & Jane, 1999) and reverse knowledge transfer (Singh, 2007). Here, we consider this dimension when exploring subsidiaries international R&D strategies and their economic consequences. Previously, the effects of local industry technological advantages on the economic returns to foreign and domestic R&D has been studied mainly from the point of view of the parent firm (Belderbos et al., 2015). Our study also informs the body of literature that focuses on complementarities between different R&D facilities (Rene Belderbos, et al., 2008; Cassiman & Veugelers, 2006; Kafouros et al., 2012) by providing evidence that subsidiaries R&D efforts increase absorptive capacity and 'cross-fertilization' potential with the know-how accessed through R&D conducted in the MNE group only when subsidiaries are located in innovation systems that are not technologically competitive. In a recent study, Berry (2015) explores the complementarities between subsidiary local R&D and the presence of parent firm expatriates.

She focuses on the positive role of parent firm managerial knowledge in strengthening the performance effect of subsidiary local innovative activities in subsidiaries active in leading

industries. In the current analysis, instead, we are able to observe the actual amount of R&D activities that the MNE group performs specifically for the subsidiary. That allows us to identify the real complementarities between R&D conducted locally and R&D conducted internationally at the MNE group. Finally, the current study makes a further methodological contribution by focusing on labor productivity as a performance measure which does not consider only shareholders profits maximizations (e.g. return on assets). This indicator of performance is gaining attention also among strategy scholars as it better captures the firms' capacity to create value via operational and organizational efficiency (Bertrand & Capron, 2015).

From a managerial point of view, the results suggests the necessity for the subsidiary and headquarter management to continuously monitor the relative strength of the local innovation system and compare it with innovation systems where other units part of the international MNE network are located. They should jointly choose the most effective allocation of subsidiary R&D resources according to the knowledge available locally and through the MNE. Assimilation of technological know-how and expertise developed in the MNE home country might not always be the best option. Subsidiary R&D mandate should be free to evolve following the dynamics of the local innovation cluster (Cantwell & Mudambi, 2005). Nevertheless, when the MNE does possess valuable technological assets, subsidiaries managers should be aware that they can leverage their local capabilities to explore new applications of MNE knowledge that could strengthen their final impact in the local market. For policymakers, the results suggest that foreign subsidiaries may have incentives to invest resources in the national innovation system and contribute to the generation of local knowledge also when the industry environment does provide internationally competitive expertise. Initiatives to facilitate foreign subsidiaries interactions and knowledge transfer across borders with the rest of their MNE network may result in simultaneous increases in complementary R&D activities carried out locally by subsidiaries.

The current study is no**t** exempt from limitations, which set potential avenues for further research. First, we note that we do not observe the geographic origin of the R&D conducted by the MNE for the subsidiary, therefore we are not able to identify the leading or lagging nature of the R&D environments in which the MNE operates. Our results should be interpret as an average effect of local R&D and MNE R&D on subsidiary productivity contingent only on the technological position of the subsidiary host country. Detailed information on the type, location and quality of innovation within the MNE group, as well as on the coordination and collaborations between units, would allow for a more thorough analysis of the mechanisms of

knowledge sourcing and R&D complementarities suggested in the present study. In this regard, the integration of patent data with R&D innovation surveys could open new paths for further research. Moreover, the addition of data on product and process innovation could help to understand the different use that subsidiaries make of local and MNE R&D activities. Second, in our empirical setting we only look at R&D investments as knowledge sourcing strategy, future research could focus on other strategies such as technology licensing (Belderbos et al., 2008; Berry, 2015) and circulation of technical personnel from other units. Third, data limitations do not allow us to control for the intensity of subsidiary embeddedness in the local innovation system (Almeida, 1996; Song et al., 2011)). Future work could explore the subsidiary's linkages with the network of local engineers and the establishment of inter-firm collaborations as a further moderator in the relationship between subsidiary R&D geographic investments and productivity. Fourth, our analysis is confined to subsidiaries located in a small and open economy such as the Netherlands. Future works could examine the validity of our findings for subsidiaries located in larger countries also considering sub-national innovation systems. Finally, while we evaluate the impact of subsidiary's local R&D on subsidiary's local productivity, future research may investigate the conditional role of subsidiary's local R&D on productivity in the rest of the MNE network (Belderbos et al., 2015).

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Appendix

Table 3-A 1 Distribution of subsidiaries and R&D across industries, N=3564

Industry (Standard industrial classification code in parentheses)	% in sample	% with positive MNE R&D	Ratio (%) of MNE R&D to localR&D*	% time industry is at the frontier
Food, beverages, and tobacco (15,16)	8.53	31.9	5.8	100
Textile, apparel and leather (17,19)	2.10	32.0	8.6	0
Wood (20)	0.87	29.0	0.8	0
Paper and paper products (21)	3.98	35.9	2.4	0
Printing (22)	1.15	43.9	3.9	15
Oil (23)	0.53	47.4	37.9	0
Chemicals and pharmaceuticals (24)	11.36	28.6	3.9	0
Rubber products and plastics (25)	6.20	40.3	7.7	0
Non-metallic products (26)	3.98	38.7	14.7	0
Basic metals (27)	1.88	37.3	11.5	84
Fabricated metal products (28)	6.54	38.2	2.1	7
Machines and equipment (29)	14.06	30.1	3.0	74
Office machinery (30)	0.45	25.0	1.3	100
Electrical machinery (31)	3.37	35.8	2.4	85
Radio, TV and communication (32)	0.48	23.5	5.5	0
Medical, precision and optical (33)	2.69	39.6	3.3	38
Motor vehicles and trailers (34)	2.78	42.4	9.2	0
Other transport equipment (35)	0.84	30.0	8.0	0
Furniture manufacturing (36)	2.30	30.5	0.8	0
Construction (45)	1.80	37.5	29.8	97
Wholesale, retail and repairs (50-52)	12.07	39.3	5.0	100
Hotels and restaurants (55)	0.70	60.0	0	0
Transport and storage (60-63)	1.46	13.5	0.8	77
Post and telecommunications (64)	0.31	0.0	0.0	0
Real estate (70)	0.17	83.3	0.0	0
Computer and related activities (72)	3.23	18.3	0.4	0
Other business services (74)	6.03	31.2	22.5	33
Community and personal services (75)	0.14	20.0	0	60
Total/Average	***100***	***33.9***	***4***	***42,5***

*We consider only observations with positive local R&D

Table 3-A 2 GMM with alternative threshold of frontier (quartile of OECD R&D intensity)

VARIABLES	lagging industries Model 2	leading industries Model 3
Productivity-1	0.561***	0.760***
	(0.045)	(0.053)
Δ Labor	-0.386***	-0.548***
	(0.030)	(0.044)
Δ Capital stock	0.156***	0.338***
	(0.016)	(0.024)
R&D local	0.038	0.396***
	(0.105)	(0.153)
R&D2 local	0.037*	-0.046**
	(0.022)	(0.020)
R&D MNE	2.209***	-0.717
	(0.689)	(1.499)
R&D2 MNE	-5.141***	1.793
	(1.662)	(3.072)
R&D local x R&D MNE	1.177***	0.436
	(0.433)	(0.317)
Observations	2,407	1,157
Number of subsidiaries	1,164	697
Chi2	590832	212595
Hansen test (d.f.)	76.4 (72)	70.2 (72)
p-value	0.340	0.537
AR1	-8.602	-5.916
AR1 p-value	0	0
AR2	-0.295	0.999
AR2 p-value	0.768	0.318

One-step GMM standard errors in parentheses. The regressions contain year dummies, the level equations contain industry dummies *,**,*** indicate 10, 5 and 1 percent levels.

Table 3-A 3 GMM regression analysis with sales based labour productivity

VARIABLES	Full sample Model 1	Lagging industries Model 2	Leading industries Model 3
Productivity-1	0.540***	0.488***	0.641***
	(0.035)	(0.044)	(0.049)
Δ Labor	-0.609***	-0.547***	-0.704***
	(0.022)	(0.026)	(0.036)
Δ Capital stock	0.175***	0.138***	0.216***
	(0.011)	(0.013)	(0.018)
R&D local	0.171**	-0.048	0.211**
	(0.081)	(0.102)	(0.093)
R&D2 local	-0.026**	0.007	-0.030**
	(0.012)	(0.020)	(0.013)
R&D MNE	1.482***	1.432**	2.332*
	(0.307)	(0.558)	(1.242)
R&D2 MNE	-2.202***	-2.703**	-3.833
	(0.601)	(1.346)	(2.516)
R&D local x R&D MNE	0.488***	0.624*	0.306
	(0.165)	(0.348)	(0.277)
Observations	3,564	2,049	1,515
Number of subsidiaries	1,751	1,018	849
Chi2	11399	7060	3988
Hansen test (d.f.)	72.2 (66)	84.5 (72)	64.8 (66)
p-value	0.280	0.148	0.518
AR1	-11.78	-9.415	-7.068
AR1 p-value	0	0	0
AR2	0.532	2.029	-1.165
AR2 p-value	0.595	0.0425	0.244

One-step GMM standard errors in parentheses. The regressions contain year dummies, the level equations contain industry dummies *,**,*** indicate 10, 5 and 1 percent levels.

Table 3-A 4 GMM regression analysis without service sectors

VARIABLES	Full sample Model 1	Lagging industries Model 2	Leading industries Model 3
Productivity-1	0.667***	0.600***	0.741***
	(0.040)	(0.050)	(0.059)
Δ Labor	-0.525***	-0.462***	-0.636***
	(0.035)	(0.042)	(0.057)
Δ Capital stock	0.222***	0.128***	0.379***
	(0.018)	(0.020)	(0.031)
R&D local	0.208*	0.003	0.307**
	(0.112)	(0.146)	(0.124)
R&D2 local	-0.014	0.047*	-0.037**
	(0.016)	(0.027)	(0.016)
R&D MNE	1.177**	1.915**	0.805
	(0.479)	(0.838)	(1.453)
R&D2 MNE	-2.095***	-9.819**	-3.908
	(0.809)	(4.436)	(3.618)
R&D local x R&D MNE	0.489**	2.626**	0.509*
	(0.242)	(1.265)	(0.296)
Observations	2,641	1,732	909
Number of subsidiaries	1,107	790	424
Chi2	2049	425704	547.9
Hansen test (d.f.)	80.4 (72)	80.2 (72)	73.3 (72)
p-value	0..233	0.237	0.436
AR1	-9.671	-6.960	-6.246
AR1 p-value	0	0	0
AR2	-0.699	-1.176	-0.596
AR2 p-value	0.485	0.240	0.551

One-step GMM standard errors in parentheses. The regressions contain year dummies, the level equations contain industry dummies *,**,*** indicate 10, 5 and 1 percent levels.

Table 3-A 5 GMM regression analysis without curvilinear term for R&D local

VARIABLES	Lagging industries Model 1
Productivity-1	0.575***
	(0.047)
Δ Labor	-0.414***
	(0.031)
Δ Capital stock	0.149***
	(0.017)
R&D local	0.244***
	(0.047)
R&D MNE	1.694**
	(0.658)
R&D2 MNE	-4.511***
	(1.625)
R&D local x R&D MNE	1.093**
	(0.434)
Observations	2,049
Number of subsidiaries	1,018
Chi2	2456
Hansen test (d.f.)	72.0 (72)
p-value	0.478
AR1	-7.115
AR1 p-value	0
AR2	-1.109
AR2 p-value	0.267

One-step GMM standard errors in parentheses. The regressions contain year dummies, the level equations contain industry dummies *,**,*** indicate 10, 5 and 1 percent levels.

Chapter 4

Global market integration, strategic orientation, and foreign subsidiary divestment[23]

4.1 Introduction

The vast body of literature on multinational corporations (MNCs) has primarily studied the strategic implications of firms' international expansion, the different motives and mode of entry in foreign markets (Dunning, 1998, Brouthers & Hennart, 2007) the location choice factors (Chung & Alcacer, 2002) and the relationship between internationalization and performance (Lu & Beamish, 2004). Less effort has been devoted to understand the other side of the coin: the explanations and strategic reasons why firms divest subsidiaries in foreign countries (Boddewyn, 1979; McDermott, 2010).

The choice to divest, via assets sell-off to a third party or closure of plants abroad, is a complex phenomenon (Mata & Portugal, 2000; Benito, 1997; Barkema et al., 1996). Moreover, reliable information on divestments is not always made available by companies because of its association with failure (Palmer, 2004). Previous studies have recognized poor performance, both at the firm and subsidiary level (Berry, 2013; Duhaime & Grant, 1984; Markides, 1992), to be correlated with divestments (Pennings & Sleuwaegen, 2000). Foreign subsidiary divestments have also been found to depend on the mode of entry (Li, 1995; Mata & Portugal, 2000), the purpose of the original investment and its orientation to the local market (Getachew & Beamish, 2017), the relatedness with the company's core business (Tan & Sousa, 2017; Berry, 2013; Li, 1995; Duhaime & Grant, 1984) and firm's prior international experience (Shaver et al., 1997; Li, 1995).

Host country environmental conditions have also been shown to affect divestment decisions. Firms are more likely to withdraw their operations from host countries with negative growth prospects (Benito, 1997; Delios & Beamish, 1999), increased factor costs (Belderbos & Zou, 2007; Pennings & Sleuwaegen, 2000), institutional instability (Henisz & Delios, 2001; Jensen, 2003), deteriorated policy environments (Blake & Moschieri, 2017) and asymmetries with political freedom and transparency in the home country (Soule et al., 2014). Researchers have

[23] Joint work with Rene Belderbos (KU Leuven), Leo Sleuwaegen (KU Leuven) and Shubin Wu (University of Liverpool)

also examined the contribution of the subsidiary to the MNCs manufacturing network (Belderbos & Zou, 2009; Chung et al., 2013), arguing that manufacturing subsidiaries that provide growth platforms or switching flexibility under macroeconomic uncertainty may be less likely to face divestment.

While extant research has examined the role of the host country environment, surprisingly little attention has been given to broader global trends in competition, trade and foreign investment, which are likely to affect MNCs' strategic orientation and the underlying drivers of divestment decisions (Benito, 2005). In a number of industries, such as electronics and textiles, global liberalization and globalization processes and the associated falling trade barriers (Krueger, 1995) in conjunction with declining transportation and communication costs and convergence in consumer demands (Hummels, 1999) have spurred the development of globally integrated markets. Such markets are characterized by intensified competition and cost and efficiency pressures, pushing MNCs to adopt global efficiency strategies (Johansson & Yip, 1994) and to locate manufacturing activities for the world market in the best locations (Krugman, 1980; Porter, 1986; Yip, 1989). In other industries, such as the food industry, world markets remain largely fragmented due to heterogeneous consumer preferences and host country regulation. MNCs competing in such industries are more likely to adopt local responsiveness strategies to cater to heterogeneous consumer demands (Ghoshal, 1987, Birkinshaw, 1995).

In the present study, we contribute by arguing and demonstrating that such diverging trends in global trade and market integration and the possible associated strategic orientation of MNCs have important repercussions for the drivers of divestment decisions. Specifically, we focus on host country factor costs and local demand. For these two divestment drivers we are able to draw clear theoretical predictions of their link with global trade integration by applying the integration-responsiveness framework (Prahalad and Doz, 1987). We argue that in globally integrated industries, divestment decisions will be more strongly driven by high labor costs, as cost and efficiency pressures are mounting. In contrast, in industries with a less pronounced trade integration path and remaining market differences, local market conditions will be the prime driver of affiliate divestment decisions.

Although MNCs are likely to respond to global integration trends in an increasingly interconnected world (Hennart, 2007; Porter, 1986; Yip, 1989, 2003; Kim & Aguilera, 2015; Wiersema & Bowen, 2008), heterogeneities in strategic approaches among MNCs remain present. These relate to idiosyncratic organizational capabilities (Nelson, 1991), unique firm's

specific advantages and product offerings (Grant, 1991), different managerial mindsets (Nadkarni et al., 2011) and governance structures (Hoskisson et al., 2005). These factors can affect firms' need or readiness to respond to global changes (Harzing, 2000; Bartlett & Ghoshal, 1989; Birkinshaw et al., 1995). A second contribution of the current paper is that we show that: 1) global trade integration is associated with the adoption by MNCs of a (revealed) strategic orientation towards efficiency, 2) MNCs that have aligned their strategic orientation to the global industry environment show the most pronounced pattern of divestment behavior in terms of a responsiveness to labor costs in integrated industries and to local demand in fragmented industries.

To our understanding, this is the first study that brings together in one empirical framework the host country, subsidiary, MNC and global industry dimensions to explain foreign subsidiaries' divestments. We test our predictions using a comprehensive panel dataset of 3'418 Japanese manufacturing subsidiaries operating in 56 countries during the period 1990-2004.

4.2 Conceptual framework and Hypotheses

4.2.1 Determinants of foreign divestment

Research on divestments and relocations of multinational's subsidiaries is still relatively scarce, but the attention for these phenomena has significantly increased over time (Lee, Kuse, & Castro, 2005; McDermott, 2010). Prior research has grouped drivers of divestment decisions at the firm, subsidiary, industry and host country level (Delios & Beamish, 2001; Li, 1995; Mata & Portugal, 2000). At the firm level, recent work taking a real option perspective has suggested that firms may be reluctant to divest under uncertainty, in particular if the subsidiary has a platform function in the host country and contributes to network flexibility by increasing the options for production relocation (Belderbos & Zou, 2009). In contrast, firms with an extended manufacturing network may also face lower barriers to exit as they are less dependent on any single foreign production operation (Bernard & Jensen, 2007; Berry, 2009). Faced with the fixed cost of relocation, financially stronger firms carry out divestment decisions more easily and are found to profit more from the relocation of businesses units (Belderbos, 2003; Pennings & Sleuwaegen, 2000). In line with the literature on the liability of foreignness, previous experience of the firm in the host country is found to reduce the probability of subsidiary divestment. MNEs that are acquainted with the host country business environment and local

partners are better able to deal with unexpected developments in the host country (Li, 1995; Shaver et al., 1997; Zaheer, 1995).

From the perspective of the subsidiary, poor performance is empirically shown to be a strong predictor of divestment decisions (Duhaime & Grant, 1984; Markides, 1992). Subsidiaries unrelated to the firm's core business activities are more likely to be divested (Chang & Singh, 1999; Doukas & Lang, 2003; Li, 1995) as firm's core intangible resources cannot be shared or are not directly transferable to the subsidiary (Tan & Sousa, 2017; Berry, 2013). Other empirical research has found a positive relationship between the size of the foreign subsidiary' and its survival, as large sunk cost investments deter firms from exiting the markets (Belderbos & Zou, 2009; Chen & Wu, 1996; Li, 1995; Mata & Portugal, 2002). Similarly, important investments in human capital deter subsidiary divestment (Mata & Portugal, 2002). In addition, the mode of entry and ownership structure influence subsidiary's chances to survive. Acquisitions and joint ventures experience higher divestment hazards than greenfield investments and fully owned subsidiaries because of the difficulties coordinating with investment partners or agreeing on shared objectives (Li, 1995; Mata & Portugal, 2002).

From the perspective of the host country environment, empirical research has found multinational firms to maintain their operations in countries with stable institutions (Henisz & Delios, 2001; Jensen, 2003), and a favorable political environment (Blake & Moschieri, 2017) with similar levels of freedom and transparency than the home country (Soule et al., 2014).[24] The probability of divestment is lower when local demand in the country is growing (Benito, 1997; Shaver et al., 1997)[25]. Rising labor costs in the host country, on the other hand, undermine profitability and reduce the chances of survival of subsidiaries (Belderbos & Zou, 2007; Pennings & Sleuwaegen, 2000).

4.2.2 The impact of market integration and MNC strategic orientation on divestment

Multinational firms face a fundamental strategic tension between pressures to reduce costs via global integration of activities and pressures for local responsiveness to meet different host country demands (Bartlett & Ghoshal, 1989; Prahalad & Doz, 1987). Firms can reduce costs

[24] In a recent study on Japanese subsidiary exits from Africa, Getachew and Beamish (2017) show that diversity in investment purposes and market orientation can increase foreign subsidiaries survival in countries with institutional voids.

[25] The size of the market is consider an important factor to attract FDIs (Dunning, 1980). However, once the given market size is considered attractive enough for the initial investment to be undertaken, it is the ability of the country to remain attractive by growing that ultimately influences the decision of the firm to remain in the market.

and achieve global efficiency by adopting a 'global strategy' offering a standardized product to distribute to an integrated global marketplace. As the products offered do not vary from market to market, 'global' firms do not need to operate all value activities of the production process in each location. Instead, they can develop an integrated network of subsidiaries spread in few locations to exploit differential comparative advantages between countries (Porter, 1986; Dunning, 1981). This strategy allows the concentration of single operations in large specialized subsidiaries to maximize the benefits from economies of scale (Porter, 1986). Firms with a 'global strategy' achieve cost efficiency by manufacturing their products in subsidiaries located in countries where factor costs are low and export from there to the international markets via their integrated distribution network.

Firms that choose to maximize local responsiveness adopt a country 'localization' strategy and develop activities close to their markets. This has advantages when firms encounter substantial cultural, economic and regulatory differences across countries. Subsidiaries of firms with a market localization strategy tend to serve their local market exclusively, with relative autonomy from headquarters and the international network of the MNC. This might penalize the global efficiency of the firm as it incurs duplication costs of managing a constellation of independent subsidiaries. The gains from such strategy derive from better coverage and value extraction from the market.

The most appropriate solution between 'global' and 'localized' strategies ultimately depends on firms specific capabilities, competitive pressure and structural forces such as market integration that differ from industry to industry (Birkinshaw et al., 1995). There are several industry drivers that bring a firm to choose for a global strategy. The presence of global competitors in the industry can force firms to coordinate their international activities if they want to respond to multi-markets threats (Wiersema & Bowen, 2008; Knickerbocker, 1973). Firms move toward 'global strategies' because of cost drivers such as economies of scale and decreasing transport costs caused by changes in industry production technologies (Birkinshaw, et al., 1995). Homogenization of consumer taste across geographic markets is another important driver of 'global strategy' adoption. An increased transfer of information across borders and the spread of global media have contributed to the standardization of demand across countries (Levitt, 1983; Belk, 1996). In industries with demand convergence towards homogeneous products, multinational firms can implement a global marketing strategy (Zou & Cavusgil, 2002; Hultman et al., 2009; Schmid & Kotulla, 2011) where they standardize their product offerings, promotional mix and pricing across geographic markets under a unique brand

(Johansson & Yip, 1994). The uniform response pattern of customers around the world allows multinational firms to adopt effective global strategies that target each market without the need to adapt products and services.

Economic liberalization and deregulation are another important driver of 'global' strategies. National technical standards, trade restrictions such as import tariffs, quotas and local content requirements imposed by local governments prevent 'global' firms from selling their standardized products or manufactured elsewhere (Doz, 1979). In an early study, Belderbos and Sleuwaegen (1998) have shown that Japanese electronics firms' foreign direct investments in the European Community (EC) during the 80s were mostly caused by EC anti-dumping actions and voluntary export restraints (VERs). As the only option to overcome export barriers and access the European markets, tariff-jumping FDIs were used in substitution of exports from Japan.

All globalization drivers, but particularly trade liberalization have affected global trade and investment. During the last two decades, the world has witnessed a progressive fall in tariff and non-tariff restrictions. This wave of trade liberalization, coupled with reduction in transport and administrative costs, have had positive consequences for the global integration of markets. The creation of interlinkages between national markets made it easier to establish a global marketplace. The subsequent growth in international competition of global players with the convergence in consumer taste and product quality world-wide have substantially increased the volume of international trade. However, not all industries have become equally global, and levels of international trade intensities can differ substantially across industries (Wiersema & Bowen, 2008; Morrison & Roth, 1992).

There is a growing stream of research looking at the impact of global market integration on the strategies and organizational structure of MNCs (Verbeke et al., 2016). Most of these studies emphasize that there should be a fit between the environment in which the firm operates, with strategies translated into corresponding organizational architectures (Hill, 2016). This contingency approach is clearly reflected in the integration-responsiveness framework outlined above (Prahalad and Doz, 1987). Under this framework, MNCs assign different strategic importance to production costs and local costumer needs according to the level of integration in the industry. Consequently, we expect trade integration to affect mostly subsidiary divestment drivers related with local factor costs and local demand, while for other potential

factors influencing divestment decisions, such as political stability or subsidiary ownership, we do not have clear theoretical arguments to presume a link with trade integration.

According to the integration-responsiveness, relevant differences across geographic markets level off in integrated industries and the advantages of localization strategies in which products are tailored for the local market become less important (Dunning, 1980). It follows that the link between the subsidiary and local market demand becomes weaker in a globally integrated industry. In such industries, firms are pushed to maximize efficiency and to spread their network of activities to take advantage of cost differences across countries. Since labor tends to account for a large portion of manufacturing costs, this stimulates the divestment of subsidiaries in countries where wage costs are high. (Belderbos & Zou, 2006; Pennings & Sleuwaegen, 2000). Hence, we expect that in integrated industries subsidiary divestment will be more dependent on host country labor costs and less on host country market conditions. While, under industry integration pressures, firms will look at the optimal wage levels across countries to reduce global costs. In fragmented industries, where products are adapted to the local market and cannot be easily traded, we expect subsidiaries operations to be affected by local market growth rather than local market size as the latter was already found sufficiently attractive by the firm at the time of the investment. This leads to the following hypotheses:

Hypothesis 1: In industries with high levels of global trade integration, there is a stronger positive relationship between country labor cost and subsidiary divestment than in industries with low levels of global trade integration.

Hypothesis 2: In industries with low levels of global trade integration, there is a stronger negative relationship between host country demand growth and subsidiary divestment than in industries with high levels of global trade integration.

4.2.3 MNCs' revealed strategic orientation

In developing the above hypotheses, we implicitly assumed that all firms in the industry would be driven to adopt the same strategy for the level of integration forces present in the industry. High levels of industry trade integration should push firms to adopt global efficiency strategies, while firms in less integrated, fragmented, industries should adopt country localization strategies. However, from the strategy literature we know that there is substantial variation in strategy across firms within an industry. Firms' strategic conduct might not always reflect the best 'fit' with the environment. Firms differ from each other in terms of the organizational capabilities they built over time by continuous decision-making and learning processes on

various hierarchical levels within the company (Teece, et al., 1997; Nelson, 1991). The literature on the resource-based view of the firm recognizes the firm as a unique mix of resources and competencies, which orients the firm's expansion in particular directions (Grant, 1991).

The 'cognitive understanding' of industry trends by the firm's top management may influence the firm's strategic position (Rugman et al., 2011). Risk adverse managers might perceive macro-level integration forces as temporary or as a threat. They may be cautious and set aside or delay any decision to adjust the organization of their operations to the new industry environment. An example of the latter behavior can be found in the strategic responses of UK firms to EU economic integration, which contrasts to the response of Japanese firms. Japanese firms saw the opportunity for regional economies of scale in the single market and moved away from a country localization strategy to concentrate their production presence in Europe. UK companies, on the contrary, kept a skeptical position on the success of the ongoing integration process and maintained their presence in multiple European countries for a longer period (Hood & Young, 1987).

In spite of the findings that firm-specific conditions and competitive dynamics might affect the diversity in strategic outcomes within the same industry, several scholars claim that when industry forces become stronger, the difference in performance between firms that adopt strategies aligned with the dominant forces and firms that don't becomes wider. As a result, there is growing convergence towards a restricted number of optimal strategic positions in the same industry (e.g. Short et al., 2007). This implies that in the presence of a strong tendency towards global trade integration firms would move towards adopting global efficiency strategies instead of country oriented localization strategies (Harzing, 2000; Birkinshaw, et. al, 1995; Johansson & Yip, 1994)

Hypothesis 3: Global trade integration is positively associated with the adoption by MNCs of a strategic orientation towards efficiency.

Strategic alignment, in our case the fit between the global business environment and the strategic orientation of the MNC, has been identified as an important performance driver (Luo et al., 2001). The benefits derive from a better exploitation of profit opportunities through arbitration and relocation of activities in response to cost differences across countries. We therefore expect the mechanisms described in our first two hypotheses to emerge more clearly

when the strategic orientation of the MNC is aligned with the industry integration forces. Hence, we suggest two additional hypotheses:

Hypothesis 4: In industries with high levels of global trade integration, there is a stronger positive relationship between host country labor cost and subsidiary divestment for MNCs with a strategic orientation towards efficiency than for MNCs without such an orientation.

Hypothesis 5: In industries with low levels of global trade integration, there is a stronger negative relationship between host country demand growth and subsidiary divestment for MNCs with a strategic orientation towards localization than for MNCs without such an orientation.

4.3 Methods

4.3.1 Data and Sample

Foreign subsidiary data were obtained from different editions of the Directory of Overseas Affiliates, published by Toyo Keizai, Inc. Toyo Keizai data are based on the responses of annual surveys sent to general managers and subsidiary managers of Japanese firms. The database provides detailed information on the subsidiary's location, date of establishment, industry, firm ownership, number of employees, and purpose of the subsidiary. Firm financial information was taken from the Development Bank of Japan, which provides financial statements of all firms listed on Japanese stock exchanges. Divestment cases of foreign subsidiaries were identified by comparing the yearly information on affiliates in the Toyo Keizai dataset and from a separate list of divested subsidiaries also published by Toyo Keizai.

We restrict our sample to manufacturing subsidiaries of listed Japanese multinational firms that operate in the same 2-digit industry of their firm. We do so for two reasons: to ensure that the subsidiary and parent company are subject to the same industry integration forces, and to exclude cases of firms that divest entire lines of non-core businesses to refocus their operations. We only include MNCs with at least two active manufacturing subsidiaries to guarantee a minimum level of multinationality and to avoid that a potential divestment decision would make the firm cease to be a multinational (in terms of overseas manufacturing presence). Consistent with prior research, we consider only subsidiaries in which the firm has at least a 10% equity stake. Subsidiaries owned by more than one Japanese firm are assigned to each of the investors. After having excluded observations for which information on subsidiaries' characteristics,

subsidiaries' host country[26] and/or firm characteristics is incomplete or missing, this resulted in a panel of 3'296 subsidiaries[27] owned by 614 manufacturing firms and active in 56 different countries and 13 industries over the period 1990-2004. The resulting dataset comprises a total of 24'769 subsidiary-year observations and includes 545 divestments. The latter implies a divestment ratio of 17% of the subsidiaries.

Table 1 and Table 2 present, respectively, the distribution of subsidiaries and divestments across countries and across industries. The largest number of subsidiaries is located in China (23%), followed by the US (13%) and seven South-East Asia countries[28] (together representing 42% of the subsidiaries), while Western European countries[29] account for nine per cent of all subsidiaries in the sample. During the observation period almost one fourth of all manufacturing subsidiary divestments (123) were recorded in the US, equivalent to 28% of all manufacturing subsidiaries active there. Japanese manufacturing subsidiaries in Western European countries experienced a similar closure rate of 26%. On the other hand, divestment rates in China and South-East Asia were lower at 6% and 14%, respectively. Tuning to the sectors represented in the dataset, subsidiaries manufacturing electrical and general machinery, transport equipment and chemical products account for 73% of our sample, with the remainder active in food, textiles, ceramic products and precision industries, among others. Electrical machinery, textiles and food are the only three sectors with a divestment rate (slightly) above 20%, while rubber, transport equipment and general machinery have the lowest divestment rates.

[26]Country labor cost is partially missing for Hong Kong, Macao, Vietnam, Malaysia, Indonesia, Cambodia, Laos, Pakistan, Bangladesh, Iran, Saudi Arabia, Qatar, Italy, Greece, Colombia, Venezuela, Peru, Bolivia, Brazil, Cote d'Ivoire, Nigeria, Tanzania.

[27] There are 84 subsidiaries owned by more than one Japanese investor

[28]Thailand, Taiwan, Malaysia, Korea, Singapore, Indonesia and Philippines.

[29] We include in this group: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

Table 4-1 Distribution of subsidiaries by country

Country	#Affiliates	#Divestments	Percentage
China	762	49	6%
US	441	123	28%
Thailand	352	38	11%
EU	310	82	26%
Taiwan	239	40	17%
Malaysia	199	24	12%
Indonesia	197	18	9%
Korea	179	37	21%
Singapore	113	26	23%
Philippines	98	12	12%
India	75	8	11%
Brazil	68	22	32%
Canada	43	16	37%
Mexico	42	13	31%
HongKong	34	2	6%
Australia	36	13	36%
Hungary	15	2	13%
CzechR	14	0	0%
Pakistan	10	3	30%
Poland	7	0	0%
Rest of World	62	17	27%
Total	**3296**	**545**	**17%**

Table 4-2 Distribution of subsidiaries by industry

Industry	#Subsidiaries	#Divestments	Percentage
Electrical Machinery	823	172	20,9%
Transport Equipment	693	87	12,6%
Chemicals	518	85	16,4%
General Machinery	376	48	12,8%
Food	186	39	21,0%
Textiles	140	31	22,1%
Ceramics	127	18	14,2%
Non-ferrous metals	118	19	16,1%
Precision Insstruments	79	13	16,5%
Paper & Printing	67	11	16,4%
Rubber Products	71	7	9,9%
Iron & steel	54	9	16,7%
Fabricated Metals	44	6	13,6%
Total	**3296**	**545**	**16,5%**

4.3.2 Variables

4.3.2.1 Dependent Variable

Our dependent variable is a binary variable that takes value 1 in year t when a foreign manufacturing subsidiary is divested by its firm via plant closure or assets sell-off. As we observe subsidiaries from 1990 to 2004, observations on surviving subsidiaries are right censored in 2004. Since we are interested in the divestment decision of subsidiaries as a response to, among others, the host country environment, we do not include closures or sell offs due to the sale, closure, or delisting of the parent firm in Japan. In such cases, we consider the observations to be right censored in the year that we no longer observe the firm.

4.3.2.2 Independent Variables

The variable *labor cost* is the monthly manufacturing wage in the host country expressed in 1000 dollars, data for host country *labor costs* (denominated in local currencies) are obtained from the International Labour Organization's Labour Statistics Database (LABORSTA). The data are then converted into dollars using the exchange rate information obtained from the United Nation's National Accounts Main Aggregates Database—Exchange Rates and Population. The variable *Country Demand Growth* is calculated as the moving average of real GDP growth rate in the preceding three years using information from the Penn World Tables 8.1.

To test our first two hypotheses, we follow the approach used by Wiersema & Bowen (2008) and compute an industry index of *global trade integration* (*GTI*) as the industry volume of world trade relative to world output. Prior studies have used exports plus imports as a measure of trade volume (World Bank, 2013; Morrison & Roth, 1992) to look at country level trade openness. However, from a global perspective, export of country A to B in an industry is simply the counterpart of imports by country B. Thus, to avoid double counting we construct the GTI index using only

$$Global\ Trade\ Integration_{tj} = \frac{world\ industry\ imports_{tj}}{world\ industry\ production_{tj}}$$

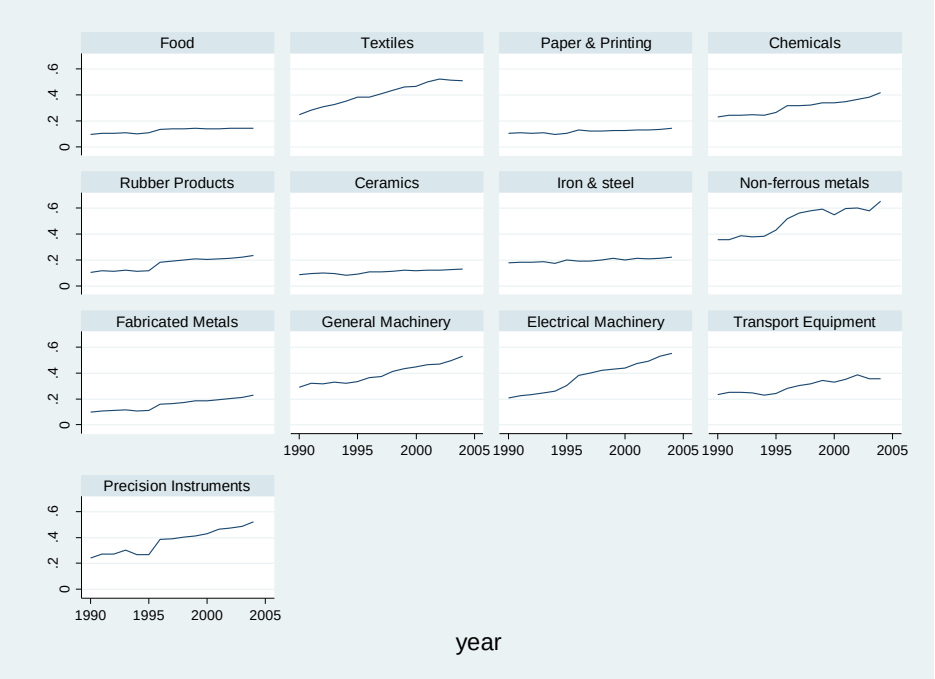
Where *t* stands for time and *j* for industry. We derived annual data on world industry production and imports from the CEPII TradeProd database (de Sousa et al., 2012) which extends the "Trade, Production and Protection" World Bank dataset (Nicita & Olarreaga, 2006) with OECD and UNIDO data. The TradeProd dataset contains industry data at the 2-digit Industry Standard

Industrial Classification (ISIC) Revision 2 level[30] for 181 countries from 1980 to 2006. We drop sectors, countries and years for which output data and/or trade data is sporadic or systematically not reported. When it is possible we integrate output data with data from the UNIDO's database INDSTAT 2 2015 version, then we use linear interpolation for country-sector series with a small fraction of missing values left. The result is a balanced panel of 29 large trading countries[31] that we use as a basis for the GTI index calculation.

Figure 1 plots the trends in trade integration for the 13 industries considered in this study; 'Electric Machinery', 'Non-ferrous Metals' and 'Precision Instruments' are the sectors that experienced the strongest increase in global integration over the observation period, while trade integration is less present in 'Ceramics', 'Paper Products & Printing' and 'Food and Tobacco' industries. To test hypotheses 1 and 3, we perform split sample analyses at the median[32] (0.34) of global trade integration. In doing so we divide the full sample into two balanced groups of observations: one group of subsidiaries active in integrated industries (GTI above the median) and another group of subsidiaries active in 'fragmented' industries (GTI below the median). We follow this approach rather than using interaction terms because this allows coefficients of all covariates to differ between two groups, guaranteeing consistent within-group estimates (Hoetker, 2007). According to hypothesis 1 and 2, we expect a stronger positive coefficient on host country labor costs and a smaller negative coefficient on host country demand growth in the subsample with integrated industries.

[30]The ISIC rev2 2-digit manufacturing sectors were linked to the industry classification used in Toyo Keyzai.
[31] The list of countries is reported in the Appendix Table A1
[32] Appendix Table A3 reports results using the mean as an alternative cut-off point. Conclusions remain the same.

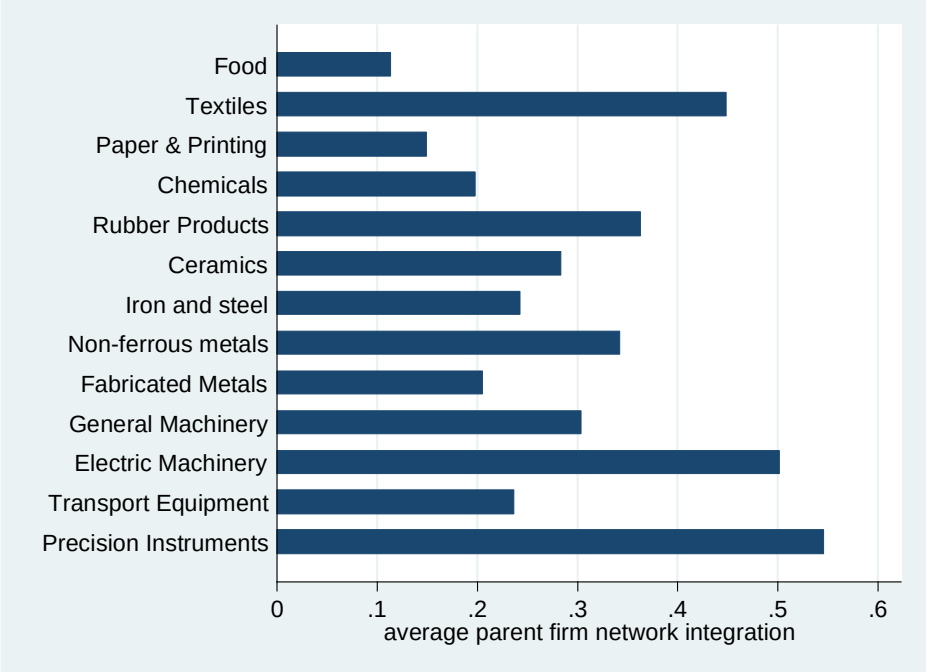
Figure 4-1 Global Trade Integration industry trends



To test Hypothesis 3, we examine to what extent firms' strategic orientation responds to the level of trade integration in the industry. We do this by regressing the share of MNCs adopting a 'global' efficiency strategy on the trade integration level of the industry in which the MNCs are active. We derive the strategic orientation of the MNC by utilizing information on the purpose of the subsidiaries as reported in the Toyo Keizai survey. For each subsidiary, the firm can report on 13 different purposes[33] such as: 'Local resources and inputs', 'Labor cost', 'Benefits provided by the host government' and so on. If a subsidiary lists 'Labor cost', 'Export to Japan', or 'Export to a third country' as its primary motivations, we take this as evidence of an efficiency strategy focusing on cost reduction and the global specialization of production. The degree to which the MNC adopts an efficiency oriented strategy is measured as the share of manufacturing subsidiaries of the firm reporting such motivations. Figure 2 reports the average values for the efficiency oriented strategy across sectors: Japanese MNCs in Precision Instruments, Electric Machinery and Textiles adopt efficiency strategies most strongly, with almost half of the manufacturing subsidiaries reporting efficiency motivations.

[33] The complete list of investment purposes with their frequencies is presented in Appendix Table A2.

Figure 4-2 MNC strategic efficiency orientation by industry



Hypotheses 4 and 5 are tested by performing an additional split sample analysis. We divide the sample in two groups, this time taking as a cut point the median of the revealed efficiency orientation of the sample firms. This leads to four subsample models for firms active in integrated or nonintegrated industries with an aligned or nonaligned strategy. For the two subsamples of firms in integrated industries, Hypothesis 4 predicts that the role of labor cost is more pronounced among efficiency oriented firms. For the two subsamples of firms in non-integrated industries, Hypothesis 5 predicts that the role of host country demand growth is more pronounced among firms with a revealed localization strategy.

4.3.2.3 Control variables

We include a comprehensive set of control variables at the host country, firm, subsidiary, and industry level that have been suggested by previous studies to influence foreign subsidiary divestments. At the host country level, we include *market uncertainty.* As divestments are costly and irreversible, highly volatile contexts present an option value in maintaining a subsidiary. The higher the uncertainty, the more firms may postpone their decision to withdraw until more information is revealed (Kogut & Kulatilaka, 1994; Belderbos & Zou, 2009; Chung et al., 2013). To construct *market uncertainty* we take the standard error of the coefficient estimated

by regressing the previous 5 years of host country's GDP (from t-5 to t-1) on time, and we divide it by the GDP value in year t to arrive at a standardized measure.

We control for country *Revealed Comparative Advantage (RCA)* calculated as a binary variable taking the value 1 if the share of country export in subsidiary's industry *i* over total country export is higher than the portion of worldwide industry *i* export to total export. Prior studies also suggest that firms try to avoid politically and institutionally unstable countries (Delios & Henisz, 2003; Berry, 2013). We control for this potential factor by incorporating Henisz's (2000) measure of *political risk.* Finally, to account for possible agglomeration externalities due to the presence of other Japanese investors in the same country, we include *Japanese agglomeration* equal to the number (in logarithm) of Japanese manufacturing subsidiaries located in the host country and active in the same industry as the focal subsidiary in year t (Belderbos & Carree, 2002; Chung & Song, 2004; Belderbos & Zou, 2009).

We include several control variables at the firm level. We control for the firm's *size* by using the logarithm of the firm's consolidated assets. Larger firms may possess greater financial resources to execute divestment decisions (Belderbos, 2003; Li, 1995; Pennings & Sleuwaegen, 2000). We also include the variable *firm's resource intensity* (Belderbos & Sleuwaegen, 2005; Caves, 2007; Chang, 1995), calculated as the ratio of general and administrative expenses (including marketing and R&D expenditures) over sales. Resourceful firms may be more competitive in foreign markets. We also control for parent firm performance, as poorly performing firms are likely to be under more pressure to divest foreign subsidiaries in corporate restructuring. *Return on assets (ROA)* is calculated as the ratio of the net income to total assets. Previous firm experience in international operations can influence divestment decisions as well (Belderbos & Zou, 2009; Benito, 1997). *International experience* is the number of years the firm has been operating in international markets and it is calculated as the difference between the focal year and the year the firm established its first foreign affiliate. We include the number of manufacturing industries in which the firm is active as a measure of *parent firm diversification*. We also control for potential co-location advantages with other value-chain activities of the firm by adding three dummy variables: *sales co-location* (a dummy that takes value 1 if the firm owns a sales office in the focal country and industry), *R&D co-location* (dummy that takes value 1 if the firm has an R&D center in the focal country), *HQ co-location* (dummy that takes value 1 if the firm has a regional headquarter in the focal country).

Finally, a set of factors at the subsidiary level that are likely to influence its survival are included. *Subsidiary size*, proxied by the number of employees (in logarithm), has been shown to be negatively correlated with divestment (Mata & Portugal, 2000; Li, 1995). We include both the linear and squared term of *subsidiary age* to control for potential 'liabilities of newness' and 'liability of adolescence' (Belderbos & Zou, 2009; Li, 1995). Previous studies suggested that subsidiaries jointly owned are more likely to be divested (Dhanaraj & Beamish, 2004; Hennart et al., 1998; Li, 1995) because of higher risks of disagreement with local partners and easier withdrawal due to the lower financial commitment. We add a dummy variable *minority owned* that takes value 1 if the firm held a minority stake (less than 50%) in the subsidiary. We also include a dummy variable *unique subsidiary* that takes the value 1 if the subsidiary is the only subsidiary owned by the firm in the focal country and industry. Firms are less likely to divest a *unique subsidiary* since they may function as 'platforms' to expand their operations in case new opportunities arise in the country (Belderbos & Zou, 2009).

MNCs' international operations are also affected by the economic health of the global industry. We include the variable *industry contraction*, constructed as a dummy variable taking the value 1 if the three years moving average growth rate of industry world production is negative. Subsidiaries in declining industries could face higher divestment pressure if firms adjust their operations when confronted with adverse industry conditions.

Table 3 and 4 report descriptive statistics and pairwise correlations. The correlation levels among the independent variables are all below 0.6, thus multicollinearity does not appear to be a major concern.

Table 4-3 Summary statistics

Variable	Mean	Std. Dev.	Min	Max
Divestment	0,02	0,15	0	1
Global trade integration	0,33	0,12	0,08	0,65
Firm efficiency orientation	0,30	0,32	0	1
Labor cost	0,91	0,87	0,01	5,23
Country demand growth	5,23	3,25	-9,75	13,76
Japanese agglomeration	3,68	1,22	0	6,04
RCA	0,49	0,50	0	1
Uncertainty	0,06	0,07	0	0,57
political risk	0,32	0,21	0	0,72
age subsidiary	11,80	9,45	1	69,00
age subsidiary sqr	228,58	352,15	1	4761,00
minority owned	0,32	0,47	0	1
subsidiary size	5,21	1,52	0	11,16
unique subsidiary	0,51	0,50	0	1
Sales co-location	0,28	0,45	0	1
RD co-location	0,05	0,22	0	1
HQ co-location	0,08	0,26	0	1
Firm experience	27,49	11,40	0	69,00
Firm diversification	2,12	1,45	1	10
ROA	0,01	0,03	-0,11	0,10
Firm resource intensity (RI)	0,20	0,09	0,01	0,65
Firm size	19,55	1,68	14,42	23,82
industry contraction	0,35	0,48	0	1

Table 4-4 Correlation table

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	divestment	1,00																						
2	GTI	0,01	1,00																					
3	Firm global orientation	0,00	0,23	1,00																				
4	Labor cost	0,06	-0,05	-0,11	1,00																			
5	Country growth	-0,05	-0,02	0,09	-0,41	1,00																		
6	Jp agglomeration	-0,02	0,37	0,10	-0,11	0,24	1,00																	
7	RCA	0,01	0,21	0,16	0,14	-0,01	0,29	1,00																
8	uncertainty	0,00	0,09	0,04	-0,24	-0,41	-0,13	-0,09	1,00															
9	political risk	0,03	-0,07	-0,08	0,32	-0,55	-0,33	-0,01	0,17	1,00														
10	age subsidiary	0,00	0,03	0,01	0,14	-0,20	-0,17	-0,01	0,09	0,25	1,00													
11	age subsidiary sqr	0,00	0,02	0,01	0,09	-0,16	-0,15	0,00	0,08	0,21	0,94	1,00												
12	minority owned	0,03	-0,06	-0,07	-0,19	0,07	-0,05	-0,12	0,06	0,03	0,01	0,00	1,00											
13	subsidiary size	-0,05	0,09	0,12	-0,13	0,02	0,13	0,15	0,04	0,00	0,26	0,21	0,05	1,00										
14	unique subsidiary	-0,01	-0,06	-0,02	0,13	-0,17	-0,33	-0,07	0,07	0,20	0,07	0,05	-0,06	-0,18	1,00									
15	Sales co-location	0,03	0,15	0,04	0,16	-0,01	0,24	0,19	-0,12	-0,08	-0,02	-0,02	-0,06	0,18	-0,26	1,00								
16	RD co-location	0,02	0,10	0,00	0,08	0,03	0,21	0,10	-0,09	-0,08	-0,02	-0,03	0,02	0,16	-0,20	0,30	1,00							
17	HQ co-location	0,02	0,10	-0,03	0,10	0,03	0,25	0,13	-0,12	-0,12	-0,06	-0,06	0,01	0,10	-0,24	0,29	0,40	1,00						
18	Firm experience	0,01	0,20	-0,04	-0,02	-0,06	0,06	0,04	0,07	0,00	0,29	0,30	0,01	0,26	-0,24	0,28	0,18	0,17	1,00					
19	Firm diversification	0,01	0,15	0,02	-0,03	-0,02	-0,02	-0,01	0,04	-0,01	0,05	0,05	0,04	0,16	-0,27	0,32	0,22	0,20	0,40	1,00				
20	ROA	-0,03	-0,09	-0,05	0,04	0,01	0,00	-0,04	-0,05	0,04	0,03	0,02	-0,04	-0,01	0,04	-0,07	-0,06	-0,06	0,00	-0,09	1,00			
21	Firm resource intensity	0,01	-0,04	-0,09	-0,01	0,03	-0,02	-0,02	-0,01	-0,08	0,07	0,08	-0,06	-0,07	0,01	0,13	0,09	0,04	0,18	-0,01	0,00	1,00		
22	Firm size	0,01	0,04	-0,14	-0,03	-0,02	0,00	0,00	0,00	0,00	0,07	0,08	0,04	0,36	-0,33	0,44	0,32	0,30	0,58	0,57	-0,04	0,13	1,00	
23	industry contraction	0,00	0,13	0,03	0,00	-0,03	-0,03	0,03	0,05	0,00	0,03	0,03	-0,03	0,00	0,00	0,01	-0,02	-0,01	0,03	0,02	-0,17	-0,02	-0,01	1,00

4.3.3 Model Specification

Our dependent variable, divestment, is a non-repeatable event that can only be observed during the period of analysis (1990-2004). This leads to a right-censoring problem in the data that can be dealt with survival analysis techniques, such as proportional hazard models. In these models the event's hazard rate (the probability of an event to occur) results from the multiplicative effect of subject characteristics and an underlying hazard function for all subjects. In our case, however, subsidiaries' survival times are grouped into discrete, yearly, time intervals, while proportional hazard models assume continuous time intervals. We therefore estimate discrete-time survival models. Such models can be estimated as regression models, as the maximum likelihood can be mathematically transformed into the likelihood of models with a binary dependent variable (Allison, 1984; Jenkins, 1995). Consistent estimates can be derived from a generalized linear model with a link complementary log-log function (cloglog) as the exact equivalent of a proportional hazard model. The (exponentiated) coefficients have the straightforward interpretation of hazard rates.

We can write the discrete-time hazard model as:

$$\log[-\log(1-h(t,X))] = z(t,X) \quad \text{or} \quad h(t,X) = 1 - \exp[-\exp(z(t,X))]$$

Where log(-log(.) is the complementary log-log link function, h(t,X) is the hazard rate, and z(t) is equal to $\beta'X + c(t)$. X represents our vector of covariates and c(t) is the duration dependence component that defines the underling hazard function. C(t) is a function of time interval t and is represented by variables that are added to the model as regressors[1]. There is no a priori restriction to the definition of c(t): one can specify it as logarithm of time, an nth order polynomial of time, or non-parametrically (as in the Cox model in continuous-time). We opt for a quadratic specification: we incorporate subsidiary age and subsidiary age squared in our specification (Li, 1995). As a sensitivity test, we experiment with a fully non-parametric baseline hazard function by adding a set of dummy variables for each duration interval.

All variables are lagged by one year to allow for managerial response time and a proper time ordering. Year and industry dummies are included to control for macroeconomic shocks and industry specific effects. Standard errors are clustered at the subsidiary level to account for heteroscedasticity and autocorrelation.

[1] Unless the hazard rate is constant, in that case no time variable needs to be specified.

4.4 Empirical Results

Results from the cloglog models examining the differential effects of *labor cost* and *country demand growth* on the probability of subsidiary divestment across types of industries are presented in Table 5. Model 1 shows the results for the full sample, Model 2 and 3 shows the results for subsidiaries in integrated vs non-integrated (fragmented) industries. The log-likelihood ratio test between the full sample log-likelihood and the sum of the integrated and fragmented industries log-likelihoods shows that split sample analysis is a better fit for the data (Allison, 1999). In the full sample Model 1, *labor cost* and *country growth* are important factors of divestment decisions. As expected, the coefficient of *labor cost* is positive and significant while the coefficient of *country growth* is negative and significant. A more nuanced picture emerges once we divide between industries with high vs low levels of trade integration. The coefficient on labor cost is highly significant in Model 2 (integrated industries) but is no longer significant in Model 3 (fragmented industries), while the coefficient of country growth is highly significant in model 3 (fragmented industries) with a coefficient of -0.1 and only marginally significant (at the 10% level) with a smaller coefficient (-0.06) in Model 2 (integrated industries). These patterns provide qualified support for Hypotheses 1 and 2.[2]

[2] Because we are estimating non-linear models with unequal variance between groups, statistical tests to compare coefficients across groups are unfortunately not available (Hoetker, 2007).

Table 4-5 Hazard model of subsidiary divestment: integrated vs non-integrated industries

	Full sample Model 1	Integrated Industries Model 2	Non-integrated Industries Model 3
Labor costs	0.248***	0.345***	0.152
	(0.068)	(0.092)	(0.101)
Country demand growth	-0.091***	-0.065*	-0.103***
	(0.022)	(0.035)	(0.030)
Jp agglomeration	-0.154***	-0.179**	-0.106
	(0.052)	(0.074)	(0.075)
RCA	0.093	0.086	0.152
	(0.101)	(0.147)	(0.143)
Country uncertainty	-1.869**	-3.507***	-0.177
	(0.887)	(1.292)	(1.165)
Country risk	0.120	0.165	0.175
	(0.280)	(0.412)	(0.401)
Subsidiary age	0.079***	0.065**	0.093***
	(0.018)	(0.026)	(0.026)
Subsidiary age sqr	-0.002***	-0.002**	-0.002***
	(0.001)	(0.001)	(0.001)
Minority owned	0.568***	0.584***	0.569***
	(0.093)	(0.130)	(0.135)
Subsidiary size	-0.298***	-0.301***	-0.290***
	(0.036)	(0.052)	(0.051)
Unique Subsidiary	-0.433***	-0.283*	-0.594***
	(0.110)	(0.158)	(0.150)
Sale co-location	0.226*	0.218	0.253
	(0.122)	(0.173)	(0.177)
RD co-location	0.178	0.335	-0.686
	(0.212)	(0.260)	(0.500)
HQ co-location	-0.088	-0.172	-0.043
	(0.189)	(0.249)	(0.307)
Firm experience	-0.001	-0.001	-0.005
	(0.005)	(0.008)	(0.008)
Firm diversification	-0.081*	-0.133**	-0.026
	(0.042)	(0.054)	(0.067)
Firm ROA	-5.548***	-4.496**	-6.507**
	(1.532)	(1.874)	(2.656)
Firm resource intensity	0.428	-0.328	1.273
	(0.684)	(0.942)	(0.975)
Firm size	0.072	0.144**	0.013
	(0.046)	(0.067)	(0.066)
Industry contraction	-0.009	0.224	-0.066
	(0.114)	(0.172)	(0.152)
Constant	-3.242***	-4.288***	-2.593*
	(0.967)	(1.515)	(1.366)
Observations	24769	11947	12822
Nonzero outcomes	545	285	260
Model chi-square	391.6	281	170.1
Log likelihood	-2442	-1224	-1194
LR test Model 1 vs Models 2,3	48.03**		

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year and industry dummies.

In hypothesis 3, we argue that firms will be more inclined to adopt efficiency oriented strategies in integrated industries. In Table 6 the results of a contingency analysis report a clear and significant alignment of MNCs' strategic orientation with industry characteristics. The Pearson's chi-squared test rejects the hypothesis that rows and columns are independent. The observed absolute frequency of subsidiaries of efficiency oriented firms in integrated industries (the lower-right cell) is 19% higher than the expected frequency, in support of Hypothesis 3. Similarly, subsidiaries of firms with a localization strategy have an observed 20% higher frequency in fragmented industries.

The frequency-based test in Table 6 does not take into account possible firm-level heterogeneity in strategy formulation. To control for such influences, we conduct a multivariate analysis relating firm-year level strategy to industry trade integration and a set of firm characteristics and time dummies. Results reported in Table 7 show a positive and highly significant coefficient of industry integration, offering strong support for the notion that MNCs align their strategy to the global industry environment, in line with Hypothesis 3.

Table 4-6 Co-occurrence of industry trade integration and MNC efficiency vs. localization orientation

Industry **Firm's strategic orientation**	Integrated Efficiency	Integrated Localization	Not integrated Efficiency	Not integrated Localization
Observed frequency	7053 *(59%)*	4894 *(41%)*	5052 *(39%)*	7770 *(61%)*
Observed/expected frequency	1.21***	0.80***	0.81***	1.19***

n=24769, *** Indicate p-value for the Chi –squared test for the null hypotheses of being independent

[a] relative frequency of firm strategic group within industry integration type

Table 4-7 MNC efficiency orientation and industry trade integration

	Efficiency orientation
Industry trade integration	0.660***
	(0.117)
Firm experience	0.003**
	(0.001)
Firm diversification	0.007
	(0.012)
Firm ROA	-0.300
	(0.387)
Firm resource intensity	-0.181
	(0.139)
Firm size	-0.049***
	(0.011)
Industry contraction	-0.011
	(0.015)
Constant	1.073***
	(0.202)
Observations	5,781
F-test	4.35***
R-squared	0.078

Dependent variable is the share of efficiency oriented manufacturing subsidiaries of the MNC. Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.01. Regression includes year dummies

Table 8 report results of four-way split-sample analysis of divestment to test Hypotheses 4 and 5. The two log-likelihood ratio tests show that splitting the samples as a function of MNC strategic orientation provide a better fit for the data in integrated industries – but this is not the case in fragmented industries. In Model 2a (integrated industries – efficiency orientation), the coefficient on *Labor cost* is significant at the 1% level with a point estimate of 0.448, almost twice as large as the coefficient in Model 2b (integrated industries – localization orientation). This finding offers support for Hypothesis 4. In fragmented industries, Model 3a and 3b, the coefficient of *country growth* is negative and significant only for firms with localization strategies, in support of Hypothesis 5.

Table 4-8. Hazard model of subsidiary divestment: integrated vs. non-integrated industries and efficiency oriented vs. localization oriented MNC strategies

	Integrated Industries		Non-integrated Industries	
	Efficiency Model 2a	Localization Model 2b	Efficiency Model 3a	Localization Model 3b
Labor costs	0.448***	0.265**	0.085	0.238*
	(0.131)	(0.131)	(0.176)	(0.130)
Country demand growth	-0.055	-0.082	-0.066	-0.142***
	(0.044)	(0.060)	(0.043)	(0.042)
Jp agglomeration	-0.166*	-0.173	-0.032	-0.102
	(0.100)	(0.115)	(0.133)	(0.091)
RCA	0.072	0.027	0.259	0.065
	(0.206)	(0.218)	(0.238)	(0.192)
Country uncertainty	-3.297**	-5.012**	0.324	-0.443
	(1.648)	(2.428)	(1.795)	(1.540)
Country risk	-0.122	0.697	0.836	-0.345
	(0.505)	(0.736)	(0.567)	(0.572)
Subsidiary age	0.076**	0.052	0.121**	0.066**
	(0.035)	(0.044)	(0.047)	(0.032)
Subsidiary age sqr	-0.002*	-0.002	-0.003*	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)
Minority owned	0.654***	0.549**	0.678***	0.546***
	(0.168)	(0.218)	(0.205)	(0.184)
Subsidiary size	-0.353***	-0.197**	-0.273***	-0.306***
	(0.063)	(0.093)	(0.092)	(0.061)
Unique Subsidiary	-0.487**	0.050	-0.596***	-0.555***
	(0.210)	(0.246)	(0.219)	(0.213)
Sale co-location	0.129	0.324	0.155	0.309
	(0.230)	(0.248)	(0.265)	(0.236)
RD co-location	0.575*	-0.297	-0.723	-0.748
	(0.334)	(0.534)	(0.819)	(0.663)
HQ co-location	-0.430	0.284	-0.240	0.002
	(0.318)	(0.408)	(0.626)	(0.363)
Firm experience	0.014	-0.029**	0.009	-0.012
	(0.010)	(0.014)	(0.013)	(0.011)
Firm diversification	-0.216***	0.106	-0.122	0.045
	(0.064)	(0.109)	(0.114)	(0.094)
Firm ROA	-5.177**	-3.194	-2.253	-7.831***
	(2.273)	(3.388)	(4.972)	(2.966)
Firm resource intensity	0.407	0.288	0.553	1.672
	(1.556)	(1.264)	(1.787)	(1.163)
Firm size	0.093	0.251**	0.068	0.053
	(0.088)	(0.122)	(0.099)	(0.091)
Industry contraction	-0.126	0.675**	0.049	-0.129
	(0.237)	(0.270)	(0.226)	(0.210)
Constant	-4.250*	-5.665**	-4.959**	-3.215
	(2.202)	(2.344)	(1.936)	(1.983)
Observations	7053	4894	5052	7770
Nonzero outcomes	179	106	110	150
Model chi-square	222	108.5	108.2	133.1
Log likelihood	-741.4	-456.9	-493.5	-684.8
LR test Model 2 vs Models 2a,2b	52.26**			
LR test Model 3 vs Models 3a,3b			35.65	

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year and industry dummies.

Several control variables appear to affect subsidiaries' divestment decision in Tables 5 and 8. Small operations are more likely to be divested, as do joint ventures, consistent with the findings of Dhanaraj and Beamish (2004).. Similarly to Li (1995) and Belderbos and Zou (2009), we find in almost all models that subsidiaries are generally less likely to survive as they get older, which may be related to organizational inertia (Hannan, 1998) or increasing competitive pressure and divestment hazards over time. The effect of age on divestment decreases with time and eventually turns negative at 20 years in the full sample model, perhaps because subsidiaries that have survived for a long time have proven to be well positioned in their host country.

Differential effects of divestment drivers are also observed depending on industry trade integration and firm strategy. A subsidiary' role as a 'country platform' increases the chances of survival, and it does so more significantly when industries are fragmented and local presence is important. The coefficient of *market uncertainty* is negative and significant only in integrated industries. This finding is somewhat surprising as one may expect that host country-specific sunk costs and investment hysteresis are higher in fragmented industries and under localization strategies (Kogut & Kulatilaka, 1994; Belderbos & Zou, 2009; Chung et al., 2013).

Japanese agglomeration economies reduce the divestment hazard of foreign subsidiaries in integrated industries. By collocating manufacturing activities with other Japanese firms, multinational firms can generate external economies of scale and cost reduction via common pools of suppliers and labor ((Belderbos & Carree, 2002; Chung & Song, 2004). *Firm diversification* is another factor that is more relevant for subsidiaries of aligned firms in integrated industries. Perhaps such subsidiaries take on a more flexible role in MNCs' integrated manufacturing network and can accommodate shifts in product mix and specialization. Finally, we observe that return on assets tends to reduce the probability of divestment, most strongly for firms with an aligned strategic orientation, both in fragmented and integrated industries.

4.5 Supplementary Analysis

We conducted a number of supplementary analyses to examine the robustness of our findings. The results are reported in the Appendix. A first test relates to an alternative measure of global market integration. An important structural force that drives firms to adopt global efficiency driven strategies is the standardization of market demand worldwide (Birkinshaw, et al. 1995; Yip, 1989). Consumers across geographic markets increasingly demand products of the same

quality and characteristics. This facilitates uniform branding, advertising and product specification. Firms active in industries where convergence of demand and tastes are salient are presented with the opportunity to produce a uniform product for export in locations where costs are minimized. Hence, global market integration intensifies competition, which eventually leads to a unique quality standard in the industry.

Hence, an alternative measure of global market integration is global quality convergence, which we measure as *export quality convergence* (EQC) at the industry level. Data for export quality are taken from the recently developed International Monetary Fund (IMF) Export Quality Database (Henn et al., 2017). The IMF followed Hallak (2006) and estimated a set of quality parameters[3] for 178 countries and 625 4-digit SITC exported products over the period 1962-2010. We group the products exported by each country into the 13 industries distinguished in this study and take the export quality median for every country-year-industry combination. We construct the variable EQC as the industry-year inverse of the coefficient of variation of export quality across countries[4]. The quality convergence measure has a correlation of 0.6 with trade integration, indicating that, as expected, convergence in local demands across countries is associated with the process of trade integration worldwide. Empirical results of split sample models at the mean of EQC (instead of industry trade integration) are reported in Table A4. The results are in general comparable to the results reported in Table 8, with one exception: a significant negative effect of *market growth* is observed across all firms in fragmented industries, also those firms adopting an efficiency strategy in this context. It appears that firms with an efficiency orientation also remain subject to local market demand pressure, perhaps because in production quality across locations hinder effective standardization of products and a full focus on global efficiency.

As a second sensitivity check to examine the robustness of our empirical findings, we limit our analysis to subsidiaries with at least 20 employees to ensure that the sample does not include potential wrongly assigned sales subsidiaries or distribution offices (Beamish & Inkpen, 1998). Table A5 shows broadly consistent results.

[3] The quality parameters are normalized every year at the frontier (the 90th percentile in the relevant product category) and take values from 0 to 1.1. A country has an export quality of 0.8 in a relevant product category if the estimated quality of its exports (in that category) is 20% lower than the quality level estimated at the frontier considering the quality of the same product exported by all other countries.

[4] We keep the same list of reference countries used to construct the variable trade integration.

Third, we substitute the linear and quadratic terms of age with a set of (maximum) 15 dummies for each year a subsidiary is observed in the study. The resulting regression model is the equivalent of a Cox's semi-parametric proportional hazard model with discrete time (Allison, 1984; Jenkins, 1995), where the underlying non-parametric baseline hazard function is captured by the time interval dummies. Table A6 again shows very similar results.

Fourth, subsidiaries survival in capital intensive industries might be less affected by country labor costs since labor accounts for a smaller share of total production costs. Industry differences in inputs contribution to the production function may influence our results if those are correlated with industry levels of trade integration. In this regard, the set of industry dummies should pick up the time-invariant industry characteristic of the production process, however, factor intensities may still vary across time and across countries. We try to control for that by employing a revealed industry, country specific measure of capital intensity previously developed by Wu (2011) on a similar dataset of foreign Japanese subsidiaries.

This measure is constructed as the equity capital[5] invested by the parent firm in the subsidiary at its establishment (i.e. paid-in capital) divided by the number of subsidiary's employees. Paid-in capital is used as a proxy for subsidiary capital because Toyo Keizai does not provide information on the value of subsidiaries total assets. Unfortunately, it is not possible to create a subsidiary specific measure of capital intensity since paid-in capital is missing for a lot of observations. Hence, the average of capital intensity by country and industry is taken over the cases for which the information is available. This allows us to still capture the industry and country variation in capital intensity caused by differences in country technological development and factors abundance. Table A7 shows the median of capital intensity in each industry calculated over our full sample of manufacturing subsidiaries. The textile and fabricated metal industries, two examples of labor-intensive sectors (OECD, 1987), display the lowest levels of capital intensity which gives us confidence in the goodness of our measure. We run the hazard models without observations in the last decile of the capital intensity distribution[6] to exclude subsidiaries in countries and industries with high levels of capital intensity. Table

[5] Equity capital is measured in thousands of dollars

[6] I could not restrict the sample further for attrition as for certain industries and time periods there were no more divestment events to estimate time and industry fixed effects.

A8 shows consistent results with our main model. In Table A9 we add capital intensity as a control variable7 and results reach the same conclusions.

Fifth, to further ensure that the firm is able to exercise real control over the manufacturing subsidiary and the subsidiary does not reflect just a financial position in the firm's investments portfolio, we limit the analysis only to subsidiaries for which the firm has at least 25% ownership[8]. Additionally, we consider as divestment only the sell-off of the entire equity stake, thus ignoring partial reductions in ownership. Table A10 presents the regressions with the new ownership threshold, as we can see the results are consistent with our main model.

Finally, the importance of maintaining a foothold in large strategic markets might still partially balance out pressures from global integration. Therefore, the MNCs process of restructuring international operations to achieve cost efficiency could start from those subsidiaries that do not already possess direct access to a large pool of customers. In that case we would expect the level of local demand to moderate negatively the effect of labor cost on divestments in integrated industries. We test this by adding an interaction term between the variable host country labor costs and the variable (logarithm of) real host country GDP. Table A11 presents the results of the alternative specification including the GDP level interaction; the variables labor costs and GDP are mean-centered to ease interpretation of the main effects[9]. The level of local demand does not seem to affect the pressure for cost reduction in integrated industries. With the removal of trade barriers and reduction in transport and communication costs, gains from serving a large local market are not enough to maintain operations in countries where production costs are not optimal. Automotive producer will move to Mexico to manufacture their car and benefit from low labor costs even though US has the largest market as long as the two markets are integrated and they can export back to US.

4.6 Conclusions

This paper investigates how global market integration forces affect the divestment drivers of foreign subsidiaries. In industries where barriers to trade are low and global demand is homogenous, intensified international competition exercises strong cost reduction pressure.

[7] We lose 40 observations because for certain country-industry combinations there was no information on the paid-in capital of the few active subsidiaries.
[8] Due to data constraints we cannot restrict the sample to only majority owned subsidiaries (more than 50% ownership) as we would lose 40% of the observations[8] with evident consequences on the model estimation.
[9] I consider in all regressions the full sample mean for demeaning.

Multinational firms responding to such pressures standardize their product offers for the international markets and choose the best locations for their different activities where they can realize global economies of scale. As a result, global industry integration make divestment decisions more dependent on local costs and less dependent on local market development. Our empirical results on a sample of 3'418 foreign Japanese manufacturing subsidiaries observed during the years 1990 to 2004, generally confirm these arguments. High wage costs increase the hazard of subsidiaries divestments only in globally integrated industries, while local demand growth does not influence the survival of subsidiaries in such industries. In contrast, in non-integrated, fragmented, industries, host country demand is an important driver of subsidiary survival.

Our study further takes into account heterogeneity in the strategic orientation of MNCs (Birkinshaw et al., 1995; Nelson, 1991; Rangan, 1998; Grant, 1991; Nadkarni et al., 2011). Our findings provide empirical support for the relevance of the classic Integration-Responsiveness theoretical approach (Prahalad & Doz, 1987). Firms active in industries characterized by high market integration and standardized products show a greater tendency to adopt an efficiency oriented strategy. Firms that adopt a strategy aligned with the integrated industry context show the highest sensitivity to local labor cost, while firms that adopt a strategy aligned with the fragmented industry context show the highest response to local demand growth.

Our study contributes to existing research on foreign subsidiary divestment by taking into account heterogeneity in divestment drivers due to changing global industry contexts and the alignment of MNC strategies to such contexts. Prior studies have limited attention to subsidiary characteristics, host country factors or parent firm traits ((Berry, 2013; Mata & Portugal, 2000; Benito, 1997; Li, 1995), without considering subsidiaries as part of MNCs that strategically respond to changing global business conditions (Wiersema & Bowen, 2008). Our study adds to recent studies investigating the heterogeneous drivers of subsidiaries divestments under different environmental conditions (Getachew & Beamish, 2017; Tan & Sousa, 2017; Berry, 2013; Berry, 2009).

Our findings suggest that firms will need to closely and continuously monitor how locational advantages or disadvantages at the country level change in relation to global market and industry drivers and increased competition. Policy makers aiming to attract and maintain manufacturing operations by foreign firms should realize that industry globalization forces as

well as strategic reactions by MNCs determine the significance of host country drivers for survival.

Local labor costs remain to this day an important factor in industries characterized by trade integration and market standardization. To limit the risk of being 'hollowed out', policy makers in high labor costs countries should design policies to develop and attract investments in sectors with high product differentiation and quality upgrade. In these sectors, investing foreign firms must link and adapt the manufacturing process to the host country in order to stay competitive (Coucke & Sleuwaegen, 2008), thus making less feasible subsequent decisions to substitute local production with exports from other countries. National governments might find these industrial policies more effective than unilateral impositions of trade barriers. In this sense, the current study highlights the effect of trade integration happening at the world level. Hence, actions of single governments to protect their domestic market might still not succeed in retaining foreign investments of MNCs that operate simultaneously across multiple interlinked markets. Moreover, local governments should seek to observe and understand the international strategic position of MNCs active in their country, in order to better assess how and to what extent industry globalization can jeopardize their local permanence.

The current study is not without limitations. First, we adopted a revealed measure of MNCs' strategic orientation derived from investment purposes stated for MNCs foreign manufacturing subsidiaries. While this delivered intuitive results, this measure is far from perfect. Future research may seek to complement the analysis with a specific survey at the parent firm level concerning their strategic goals and posture. Second, we were not able to use a more disaggregate classification of subsidiaries' industries. Broadly defined industries encompass a wide array of highly diverse products that are subject themselves to different integration pressures and require different strategic responses[10]. This could partially explain the heterogeneity in strategic orientations that we found in industries with same levels of integration. Third, we could not distinguish between plant closures and equity sell-off to a third party (Damaraju et al., 2015), which may put a downward bias on our results as equity sell-offs may be less driven by changes in the local environment and more by strategic repositioning. Fourth, our analysis focused on global industry drivers in combination with host country

[10] For instance, within the food sector, firms active in the brewing industry, characterized by a homogeneous product and high market concentration, will have different responses to environmental changes compared to firms from other segments of food processing with more geographically specific consumer preferences and regulations.

factors, but could not take into account subnational heterogeneity in manufacturing circumstances related to local agglomeration factors and cost developments. Fifth, we could not distinguish between types of labor to identify potential mechanism of skills upgrading of subsidiaries in high wage countries subject to integration forces (Mion & Zhu, 2012). This could downward bias our results as MNCs in integrated industries may downsize their subsidiaries and keep high skilled workers instead of divesting completely. Finally, our study is confined to the divestment behaviour of Japanese firms. It would be interesting to investigate if our findings carry over to divestment decisions by MNCs originating from other countries

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Appendix

Table 4-A 1

List of reference countries					
Australia	Finland	India	Japan	Norway	Sweden
Austria	France	Indonesia	Korea	Poland	Turkey
Canada	Germany	Ireland	Malaysia	Portugal	UK
China	Hong Kong	Israel	Mexico	Singapore	US
Denmark	Hungary	Italy	Netherlands	Spain	

Table 4-A 2

Investment motivation	Frequencies	Percentage
Local resource and input	1,423	7%
Labor cost	5,608	29%
Benefits provided by the host government	1,364	7%
Local market	9,717	50%
Export to third countries	156	1%
Export to Japan	271	1%
Following upstream or downstream enterprises	335	2%
Raising capital, avoiding exchange rate risk	33	0%
Royalties	202	1%
R&D for international markets	113	1%
New business	9	0%
Reinforce regional headquarter function	8	0%
Avoid trade friction	155	1%
Other	155	1%
Total	19549[11]	

[11] We do not have information on investment motivations for 5220 observations and 927 subsidiaries,

Table 4-A 3 Hazard model with industry integration* split on the mean.

	Full sample	Integrated Industries	Non-Integrated Industries
VARIABLES	Model 1	Model 2	Model 3
Labor costs	0.248***	0.346***	0.136
	(0.068)	(0.087)	(0.109)
Country growth	-0.091***	-0.067**	-0.114***
	(0.022)	(0.032)	(0.031)
Jp agglomeration	-0.154***	-0.150**	-0.101
	(0.052)	(0.071)	(0.080)
RCA	0.093	0.021	0.208
	(0.101)	(0.135)	(0.149)
Country uncertainty	-1.869**	-2.048*	-0.248
	(0.887)	(1.110)	(1.562)
Country risk	0.120	0.126	0.142
	(0.280)	(0.376)	(0.429)
Affiliate age	0.079***	0.061**	0.104***
	(0.018)	(0.024)	(0.030)
Affiliate age sqr	-0.002***	-0.002**	-0.003***
	(0.001)	(0.001)	(0.001)
Minority owned	0.568***	0.604***	0.533***
	(0.093)	(0.120)	(0.147)
Affiliate size	-0.298***	-0.301***	-0.289***
	(0.036)	(0.049)	(0.054)
Unique affiliate	-0.433***	-0.284*	-0.630***
	(0.110)	(0.149)	(0.159)
Sale co-location	0.226*	0.255	0.176
	(0.122)	(0.161)	(0.193)
RD co-location	0.178	0.292	-0.769
	(0.212)	(0.246)	(0.578)
HQ co-location	-0.088	-0.136	-0.055
	(0.189)	(0.233)	(0.335)
Firm experience	-0.001	0.002	-0.008
	(0.005)	(0.007)	(0.009)
Firm diversification	-0.081*	-0.122**	-0.056
	(0.042)	(0.051)	(0.075)
Firm ROA	-5.548***	-5.527***	-5.621*
	(1.532)	(1.852)	(2.953)
Firm resource intensity	0.428	-0.087	1.284
	(0.684)	(0.864)	(1.091)
Firm size	0.072	0.131**	0.007
	(0.046)	(0.062)	(0.071)
Industry contraction	-0.009	0.189	-0.114
	(0.114)	(0.155)	(0.166)
Constant	-3.242***	-4.140***	-2.302
	(0.967)	(1.462)	(1.427)
Observations	24,769	13,184	11,585
Nonzero outcomes	545	318	227
Model chi-square	391.6	304.7	158.7
Log likelihood	-2442	-1373	-1046
LR test 1 vs 2,3	46.49**		

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year and industry dummies.* It was not possible to test firm strategic orientation, because there were not enough divestment events for each period and industry in the smaller subsamples of not aligned firms.

Table 4-A 4 Hazard model using export quality convergence (EQC)

	Full sample	Integrated Industries	Non-Integrated Industries	Integrated Industries		Non-integrated Industries	
				Efficiency	Localization	Efficiency	Localization
VARIABLES	Model 1	Model 2	Model 3	Model 2a	Model 2b	Model 3a	Model 3b
Labor cost	0.248***	0.330***	0.214**	0.417***	0.260*	0.136	0.248*
	(0.068)	(0.094)	(0.104)	(0.122)	(0.148)	(0.191)	(0.127)
Country growth	-0.091***	-0.036	-0.129***	-0.009	-0.121**	-0.121**	-0.133***
	(0.022)	(0.034)	(0.029)	(0.041)	(0.061)	(0.048)	(0.039)
Jp agglomeration	-0.152***	-0.142*	-0.159**	-0.172	-0.049	-0.142	-0.133
	(0.052)	(0.082)	(0.070)	(0.105)	(0.142)	(0.129)	(0.086)
RCA	0.087	0.034	0.203	0.016	-0.200	0.284	0.173
	(0.100)	(0.143)	(0.154)	(0.196)	(0.220)	(0.252)	(0.192)
Country uncertainty	-1.864**	-3.372**	-0.458	-3.963**	-3.875	0.179	-0.703
	(0.888)	(1.437)	(1.133)	(1.845)	(2.620)	(1.742)	(1.562)
Country risk	0.119	0.717*	-0.494	0.407	1.051	-0.665	-0.552
	(0.280)	(0.402)	(0.408)	(0.490)	(0.772)	(0.614)	(0.549)
Subs age	0.079***	0.069***	0.086***	0.085**	0.059	0.104**	0.067**
	(0.018)	(0.026)	(0.026)	(0.034)	(0.045)	(0.046)	(0.032)
Subs age sqr	-0.002***	-0.002***	-0.002***	-0.002**	-0.003*	-0.002*	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Minority owned	0.567***	0.417***	0.777***	0.480***	0.484**	1.207***	0.575***
	(0.093)	(0.136)	(0.136)	(0.169)	(0.241)	(0.238)	(0.176)
Subsidiary size	-0.299***	-0.332***	-0.262***	-0.369***	-0.288***	-0.238**	-0.272***
	(0.036)	(0.053)	(0.051)	(0.062)	(0.101)	(0.094)	(0.061)
Unique Subs	-0.434***	-0.374**	-0.555***	-0.618***	0.151	-0.546**	-0.557***
	(0.110)	(0.160)	(0.151)	(0.200)	(0.276)	(0.234)	(0.201)
Sale co-location	0.224*	0.361**	0.077	0.181	0.730***	0.076	0.010
	(0.122)	(0.169)	(0.187)	(0.213)	(0.258)	(0.288)	(0.246)
RD co-location	0.176	0.224	0.015	0.536*	-0.595	0.496	-0.463
	(0.212)	(0.258)	(0.404)	(0.304)	(0.621)	(0.623)	(0.609)
HQ co-location	-0.089	-0.183	0.001	-0.484	0.560	0.644	-0.117
	(0.189)	(0.247)	(0.292)	(0.295)	(0.431)	(0.608)	(0.349)
Firm experience	-0.001	-0.001	-0.004	0.001	-0.012	0.028**	-0.020*
	(0.005)	(0.008)	(0.008)	(0.011)	(0.014)	(0.013)	(0.011)
Firm diversification	-0.080*	-0.152***	0.008	-0.214***	0.089	-0.127	0.053
	(0.042)	(0.057)	(0.061)	(0.065)	(0.120)	(0.104)	(0.091)
Firm ROA	-5.592***	-3.514*	-7.431***	-5.196**	2.114	-2.279	-8.557***
	(1.527)	(2.052)	(2.245)	(2.211)	(4.737)	(5.588)	(2.327)
Firm RI	0.414	-0.874	1.596*	-0.371	0.208	1.692	1.539
	(0.685)	(0.956)	(0.957)	(1.444)	(1.282)	(1.929)	(1.132)
Firm size	0.072	0.136**	0.028	0.095	0.197	0.171	0.077
	(0.046)	(0.066)	(0.067)	(0.079)	(0.130)	(0.134)	(0.089)
Industry contr	-0.009	0.164	-0.167	0.054	0.180	-0.066	-0.270
	(0.114)	(0.167)	(0.169)	(0.226)	(0.294)	(0.276)	(0.216)
Constant	-3.248***	-4.975***	-3.023**	-3.685**	-8.257***	-7.899***	-2.789
	(0.967)	(1.485)	(1.539)	(1.741)	(2.914)	(2.943)	(2.087)
Observations	24,769	11,925	12,844	7,748	4,177	4,357	8,487
Nonzero outcomes	545	285	260	188	97	101	159
Model chi-square	391.8	269.8	187.9	205.3	148.3	119.6	133.8
Log likelihood	-2443	-1223	-1187	-792.9	-405.1	-428.7	-735.9
LR test M 1 vs 2,3	64.69***						
LR test M 2vs 2a,2b				50.08**			
LR test M 3vs 3a,3b						45.45	

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year and industry dummies.

Table 4-A 5 Hazard model analysis: subsidiaries with at least 20 employees

	Full sample	Integrated Industries	Non-Integrated Industries	Integrated Industries		Non-Integrated Industries	
				Efficiency	Localization	Efficiency	Localization
VARIABLES	Model 1	Model 2	Model 3	Model 2a	Model 2b	Model 3a	Model 3b
Labor cost	0.291***	0.395***	0.181*	0.406***	0.387***	0.185	0.205
	(0.071)	(0.095)	(0.108)	(0.137)	(0.128)	(0.193)	(0.137)
Country growth	-0.077***	-0.046	-0.109***	-0.036	-0.057	-0.073	-0.147***
	(0.023)	(0.035)	(0.031)	(0.045)	(0.058)	(0.046)	(0.043)
Jp agglomeration	-0.126**	-0.092	-0.095	-0.139	0.029	0.073	-0.133
	(0.056)	(0.079)	(0.084)	(0.101)	(0.137)	(0.152)	(0.103)
RCA	0.045	-0.001	0.119	0.060	-0.232	0.086	0.067
	(0.108)	(0.150)	(0.158)	(0.212)	(0.225)	(0.277)	(0.215)
Country uncertainty	-1.749*	-2.065*	-0.831	-2.828*	-1.507	0.673	-1.672
	(0.923)	(1.255)	(1.411)	(1.566)	(2.141)	(2.133)	(1.872)
Country risk	0.037	0.276	-0.141	-0.115	1.010	0.177	-0.333
	(0.290)	(0.425)	(0.423)	(0.527)	(0.722)	(0.634)	(0.580)
Subsidiary age	0.572***	0.646***	0.517***	0.747***	0.496**	0.626***	0.526**
	(0.098)	(0.134)	(0.147)	(0.166)	(0.227)	(0.228)	(0.207)
Subsidiary age sqr	-0.338***	-0.34***	-0.313***	-0.488***	-0.050	-0.331***	-0.313***
	(0.049)	(0.068)	(0.074)	(0.082)	(0.119)	(0.118)	(0.096)
Minority owned	0.073***	0.056**	0.092***	0.090**	0.004	0.126***	0.066*
	(0.019)	(0.027)	(0.027)	(0.041)	(0.038)	(0.046)	(0.034)
Subsidiary size	-0.002***	-0.002**	-0.002**	-0.002*	-0.001	-0.003**	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Unique Subsidiary	-0.358***	-0.127	-0.616***	-0.238	0.022	-0.554**	-0.608***
	(0.113)	(0.160)	(0.156)	(0.212)	(0.253)	(0.236)	(0.210)
Sale co-location	0.126	0.087	0.208	0.166	0.042	-0.217	0.446*
	(0.126)	(0.174)	(0.193)	(0.239)	(0.243)	(0.297)	(0.266)
RD co-location	0.136	0.246	-1.039	0.325	0.115	-0.323	-1.653
	(0.218)	(0.263)	(0.638)	(0.348)	(0.401)	(0.804)	(1.097)
HQ co-location	-0.103	-0.093	-0.269	-0.321	0.249	0.101	-0.304
	(0.196)	(0.244)	(0.378)	(0.341)	(0.349)	(0.638)	(0.463)
Firm experience	-0.029	-0.110*	0.078	-0.218***	0.155	-0.024	0.128
	(0.049)	(0.064)	(0.085)	(0.081)	(0.127)	(0.127)	(0.116)
Firm diversification	-0.003	-0.003	-0.008	0.010	-0.027**	-0.006	-0.009
	(0.006)	(0.008)	(0.010)	(0.011)	(0.014)	(0.016)	(0.014)
Firm ROA	-5.834***	-6.165***	-6.104**	-6.958***	-2.822	-5.154	-5.510
	(1.568)	(1.879)	(2.962)	(2.303)	(3.110)	(5.167)	(3.531)
Firm RI	0.246	-1.386	2.169**	-2.171	0.354	1.125	2.592**
	(0.745)	(1.132)	(1.028)	(1.825)	(1.435)	(1.949)	(1.176)
Firm resource size	0.035	0.166**	-0.115	0.169*	0.164	0.093	-0.161
	(0.050)	(0.070)	(0.072)	(0.094)	(0.128)	(0.114)	(0.104)
Industry contraction	0.045	0.203	0.024	-0.101	0.596**	0.114	0.021
	(0.118)	(0.174)	(0.159)	(0.256)	(0.259)	(0.226)	(0.233)
Constant	-2.441**	-5.340***	0.070	-6.155***	-6.296**	-4.779**	0.809
	(1.026)	(1.574)	(1.422)	(2.241)	(2.602)	(2.142)	(2.129)
Observations	22,416	11,348	11,068	6,434	4,914	4,103	6,965
Nonzero outcomes	491	274	217	167	107	94	123
Model chi-square	299.4	221.7	155.6	216.6	92.22	108.1	106
Log likelihood	-2218	-1185	-1004	-680.9	-474.4	-418.6	-572.9
LR test 1 vs 2,3	59.82***						
LR tests 2 vs 2a,2b				58.42***			
LR test 3 vs 3a,3b						30.41	

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year and industry dummies.

Table 4-A 6 Hazard model analysis: non-parametric hazard function

	Full sample	Integrated Industries	Non-Integrated Industries	Integrated Industries		Non-Integrated Industries	
				Efficiency	Localization	Efficiency	Localization
VARIABLES	Model 1	Model 2	Model 3	Model 2a	Model 2b	Model 3a	Model 3b
Labor cost	0.286***	0.383***	0.174*	0.488***	0.287**	0.163	0.230*
	(0.066)	(0.089)	(0.100)	(0.125)	(0.130)	(0.166)	(0.134)
Country growth	-0.091***	-0.064*	-0.107***	-0.056	-0.076	-0.062	-0.156***
	(0.023)	(0.035)	(0.030)	(0.043)	(0.062)	(0.042)	(0.043)
Jp agglomeration	-0.159***	-0.181**	-0.109	-0.192**	-0.163	-0.073	-0.096
	(0.052)	(0.074)	(0.075)	(0.098)	(0.114)	(0.131)	(0.092)
RCA	0.067	0.066	0.106	0.084	0.052	0.173	0.018
	(0.100)	(0.148)	(0.140)	(0.208)	(0.224)	(0.229)	(0.191)
Country uncertainty	-1.846**	-3.349***	-0.360	-3.093*	-4.916**	0.055	-0.746
	(0.892)	(1.292)	(1.180)	(1.639)	(2.483)	(1.890)	(1.600)
Country risk	0.165	0.196	0.207	-0.079	0.698	1.008*	-0.442
	(0.284)	(0.413)	(0.409)	(0.510)	(0.734)	(0.565)	(0.582)
Minority owned	0.577***	0.584***	0.576***	0.655***	0.542**	0.665***	0.564***
	(0.092)	(0.128)	(0.133)	(0.165)	(0.220)	(0.200)	(0.182)
Subsidiary size	-0.274***	-0.287***	-0.259***	-0.336***	-0.213**	-0.181**	-0.315***
	(0.034)	(0.050)	(0.047)	(0.062)	(0.090)	(0.078)	(0.059)
Unique Subsidiary	-0.428***	-0.298*	-0.583***	-0.506**	0.060	-0.598***	-0.560***
	(0.109)	(0.156)	(0.150)	(0.207)	(0.248)	(0.214)	(0.214)
Sale co-location	0.215*	0.221	0.232	0.122	0.337	0.117	0.317
	(0.120)	(0.169)	(0.176)	(0.225)	(0.247)	(0.258)	(0.237)
RD co-location	0.187	0.341	-0.658	0.557*	-0.245	-0.616	-0.725
	(0.211)	(0.259)	(0.508)	(0.332)	(0.529)	(0.825)	(0.671)
HQ co-location	-0.087	-0.130	-0.143	-0.366	0.330	-0.324	-0.073
	(0.186)	(0.246)	(0.308)	(0.307)	(0.417)	(0.640)	(0.363)
Firm experience	-0.001	-0.002	-0.002	0.015	-0.034**	0.016	-0.012
	(0.005)	(0.008)	(0.008)	(0.010)	(0.014)	(0.013)	(0.010)
Firm diversification	-0.080*	-0.133**	-0.024	-0.219***	0.113	-0.109	0.041
	(0.042)	(0.054)	(0.068)	(0.065)	(0.110)	(0.112)	(0.096)
Firm ROA	-5.617***	-4.782**	-6.440**	-5.443**	-3.804	-1.931	-7.534**
	(1.543)	(1.870)	(2.758)	(2.296)	(3.407)	(5.144)	(3.052)
Firm RI	0.413	-0.424	1.299	0.342	0.362	0.697	1.626
	(0.673)	(0.930)	(0.942)	(1.537)	(1.258)	(1.740)	(1.135)
Firm size	0.061	0.136**	-0.003	0.078	0.270**	0.026	0.055
	(0.046)	(0.067)	(0.066)	(0.087)	(0.121)	(0.099)	(0.092)
Industry contraction	0.090	0.276	0.119	-0.088	0.717***	0.152	0.130
	(0.116)	(0.172)	(0.166)	(0.239)	(0.268)	(0.272)	(0.219)
Constant	-2.383**	-3.864**	-1.540	-3.349	-6.321**	-3.661*	-2.204
	(0.975)	(1.566)	(1.358)	(2.182)	(2.454)	(1.944)	(1.991)
Observations	24,769	11,947	12,822	7,053	4,894	5,052	7,770
Nonzero outcomes	545	285	260	179	106	110	150
Model chi-square	392.3	297.6	182.5	232.2	163.8	125.9	190.4
Log likelihood	-2443	-1222	-1193	-737.1	-455.6	-493.2	-677.5
LR test 1 vs 2,3	56.75*						
LR test 2 vs 2a,2b				58.84**			
LR test 3 vs 3a,3b						47.30	

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year, industry and period dummies.

Table 4-A 7 Median of capital intensity across industries

Industry	Capital Intensity
Food	895
Textiles	440
Paper & Printing	1632
Chemicals	2854
Rubber Products	1137
Ceramics	3386
Iron and steel	4120
Non-ferrous metals	2727
Fabricated Metals	577
General Machinery	885
Electrical Machinery	1128
Transport Equipment	1284
Precision Instruments	721

Table 4-A 8 Hazard model analysis: excluding high levels of capital intensity

	Full sample	Integrated Industries	Non-Integrated Industries	Integrated Industries		Non-Integrated Industries	
				Efficiency	Localization	Efficiency	Localization
VARIABLES	Model 1	Model 2	Model 3	Model 2a	Model 2b	Model 3a	Model 3b
Labor costs	0.250***	0.345***	0.161	0.423***	0.276**	0.129	0.199
	(0.073)	(0.098)	(0.111)	(0.146)	(0.137)	(0.200)	(0.137)
Country growth	-0.086***	-0.063*	-0.099***	-0.051	-0.083	-0.067	-0.133***
	(0.024)	(0.038)	(0.032)	(0.048)	(0.062)	(0.045)	(0.044)
Jp agglomeration	-0.140**	-0.144*	-0.102	-0.185	-0.047	0.093	-0.171
	(0.059)	(0.083)	(0.086)	(0.114)	(0.134)	(0.149)	(0.109)
RCA	0.075	0.046	0.132	0.042	-0.028	0.125	0.141
	(0.112)	(0.157)	(0.161)	(0.224)	(0.228)	(0.258)	(0.228)
Country uncertainty	-2.158**	-3.958***	-0.313	-3.605**	-5.235**	-1.217	0.096
	(0.924)	(1.368)	(1.206)	(1.795)	(2.359)	(1.960)	(1.491)
Country risk	0.080	0.187	0.074	-0.120	0.823	1.238*	-0.698
	(0.297)	(0.441)	(0.427)	(0.546)	(0.782)	(0.633)	(0.586)
Affiliate age	0.087***	0.071**	0.101***	0.093**	0.037	0.116**	0.081**
	(0.020)	(0.028)	(0.030)	(0.042)	(0.042)	(0.047)	(0.039)
Affiliate age sqr	-0.002***	-0.002**	-0.002***	-0.002**	-0.002	-0.003*	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Minority owned	0.496***	0.563***	0.457***	0.680***	0.414*	0.451**	0.468**
	(0.101)	(0.139)	(0.151)	(0.181)	(0.236)	(0.225)	(0.207)
Affiliate size	-0.315***	-0.327***	-0.297***	-0.401***	-0.151	-0.257***	-0.336***
	(0.040)	(0.055)	(0.063)	(0.067)	(0.099)	(0.099)	(0.083)
Unique affiliate	-0.446***	-0.289*	-0.629***	-0.551**	0.166	-0.487**	-0.648***
	(0.120)	(0.169)	(0.165)	(0.223)	(0.271)	(0.226)	(0.240)
Sale co-location	0.238*	0.229	0.254	0.134	0.382	0.172	0.222
	(0.135)	(0.185)	(0.202)	(0.261)	(0.258)	(0.296)	(0.281)
RD co-location	0.127	0.215	-0.892	0.357	0.005	-0.471	-1.572
	(0.229)	(0.275)	(0.651)	(0.365)	(0.497)	(0.829)	(1.158)
HQ co-location	-0.151	-0.212	-0.223	-0.440	0.198	-1.060	0.161
	(0.213)	(0.262)	(0.424)	(0.343)	(0.427)	(0.998)	(0.479)
Firm experience	-0.003	-0.003	-0.005	0.010	-0.032**	0.004	-0.012
	(0.006)	(0.009)	(0.009)	(0.012)	(0.015)	(0.015)	(0.012)
Firm diversification	-0.094**	-0.150***	-0.035	-0.234***	0.073	-0.079	0.009
	(0.046)	(0.057)	(0.080)	(0.070)	(0.114)	(0.118)	(0.099)
Firm ROA	-5.688***	-4.501**	-7.003**	-5.071**	-3.257	-4.302	-8.488**
	(1.592)	(1.920)	(2.808)	(2.352)	(3.454)	(4.801)	(3.422)
Firm RI	-0.357	-0.962	0.533	0.109	-0.716	-0.282	1.169
	(0.805)	(1.145)	(1.127)	(1.665)	(1.689)	(1.865)	(1.394)
Firm size	0.094*	0.188***	0.003	0.142	0.257**	0.061	0.076
	(0.050)	(0.070)	(0.072)	(0.095)	(0.131)	(0.107)	(0.102)
Industry contraction	0.060	0.261	0.010	-0.096	0.772***	0.176	-0.089
	(0.124)	(0.183)	(0.167)	(0.255)	(0.274)	(0.237)	(0.235)
Constant	-3.459***	-6.003***	-2.108	-5.100**	-8.389***	-4.900**	-3.158
	(1.022)	(1.651)	(1.446)	(2.271)	(2.596)	(2.100)	(2.162)
Observations	21,824	10,893	10,931	6,263	4,630	4,092	6,839
Nonzero outcomes	467	255	212	156	99	93	119
Model chi-square	358.5	264.3	152.6	221.8	91.79	105.5	110.7
Log likelihood	-2099	-1094	-981	-637.1	-431.2	-413.7	-553.7
LR tests		1 vs 2,3	49.29**	2 vs 2a,2b	52.41**	3 vs 3a,3b	32.11

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year and industry dummies.

Table 4-A 9 Hazard model analysis: controlling high levels of capital intensity

	Full sample	Integrated Industries	Non-Integrated Industries	Integrated Industries		Non-Integrated Industries	
				Efficiency	Localization	Efficiency	Localization
VARIABLES	Model 1	Model 2	Model 3	Model 2a	Model 2b	Model 3a	Model 3b
Labor cost	0.230***	0.319***	0.147	0.425***	0.245*	0.031	0.241*
	(0.069)	(0.094)	(0.104)	(0.137)	(0.131)	(0.183)	(0.131)
Country growth	-0.091***	-0.065*	-0.102***	-0.057	-0.078	-0.058	-0.143***
	(0.023)	(0.036)	(0.030)	(0.044)	(0.060)	(0.043)	(0.043)
Capital intensity	0.014	0.013	0.015	-0.012	0.027	0.111*	-0.002
	(0.021)	(0.029)	(0.030)	(0.061)	(0.029)	(0.067)	(0.032)
Jp agglomeration	-0.156***	-0.182**	-0.108	-0.165*	-0.179	-0.062	-0.100
	(0.052)	(0.074)	(0.075)	(0.100)	(0.115)	(0.131)	(0.092)
RCA	0.078	0.076	0.132	0.064	0.003	0.173	0.070
	(0.105)	(0.149)	(0.149)	(0.212)	(0.221)	(0.236)	(0.204)
Country uncertainty	-1.896**	-3.548***	-0.164	-3.445**	-4.919**	0.591	-0.554
	(0.893)	(1.292)	(1.177)	(1.659)	(2.412)	(1.761)	(1.586)
Country risk	0.122	0.192	0.146	-0.118	0.736	0.950*	-0.398
	(0.282)	(0.414)	(0.404)	(0.507)	(0.731)	(0.575)	(0.579)
Subsidiary age	0.080***	0.068**	0.092***	0.080**	0.052	0.119**	0.064**
	(0.018)	(0.026)	(0.026)	(0.036)	(0.044)	(0.047)	(0.032)
Subsidiary age sqr	-0.002***	-0.002**	-0.002***	-0.002**	-0.002	-0.003*	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Minority owned	0.562***	0.572***	0.569***	0.641***	0.545**	0.710***	0.544***
	(0.093)	(0.131)	(0.136)	(0.168)	(0.216)	(0.206)	(0.184)
Subsidiary size	-0.298***	-0.304***	-0.287***	-0.357***	-0.194**	-0.261***	-0.305***
	(0.036)	(0.053)	(0.051)	(0.063)	(0.094)	(0.093)	(0.061)
Unique Subsidiary	-0.440***	-0.293*	-0.600***	-0.495**	0.049	-0.630***	-0.560***
	(0.110)	(0.158)	(0.151)	(0.211)	(0.245)	(0.221)	(0.214)
Sale co-location	0.232*	0.227	0.254	0.150	0.332	0.146	0.308
	(0.122)	(0.174)	(0.178)	(0.233)	(0.248)	(0.269)	(0.238)
RD co-location	0.188	0.351	-0.683	0.587*	-0.295	-0.653	-0.752
	(0.212)	(0.260)	(0.500)	(0.340)	(0.536)	(0.824)	(0.664)
HQ co-location	-0.085	-0.171	-0.043	-0.436	0.275	-0.254	0.009
	(0.189)	(0.249)	(0.307)	(0.318)	(0.405)	(0.618)	(0.363)
Firm experience	-0.001	-0.001	-0.005	0.013	-0.029**	0.010	-0.012
	(0.005)	(0.008)	(0.008)	(0.010)	(0.014)	(0.013)	(0.011)
Firm diversification	-0.083**	-0.136**	-0.026	-0.221***	0.103	-0.134	0.051
	(0.042)	(0.054)	(0.068)	(0.065)	(0.110)	(0.113)	(0.098)
Firm ROA	-5.540***	-4.425**	-6.575**	-5.057**	-3.155	-1.798	-8.046***
	(1.536)	(1.878)	(2.664)	(2.274)	(3.412)	(5.033)	(2.969)
Firm resource int	0.444	-0.304	1.291	0.456	0.309	0.381	1.710
	(0.685)	(0.944)	(0.979)	(1.569)	(1.265)	(1.816)	(1.166)
Firm resource size	0.069	0.143**	0.009	0.093	0.250**	0.062	0.051
	(0.047)	(0.067)	(0.067)	(0.088)	(0.122)	(0.099)	(0.093)
Industry contraction	0.001	0.239	-0.054	-0.103	0.680**	0.046	-0.109
	(0.114)	(0.172)	(0.152)	(0.238)	(0.270)	(0.226)	(0.209)
Constant	-3.185***	-4.178***	-2.526*	-4.088*	-5.727**	-4.914**	-3.177
	(0.968)	(1.511)	(1.371)	(2.194)	(2.349)	(1.948)	(1.988)
Observations	24,739	11,932	12,807	7,045	4,887	5,052	7,755
Nonzero outcomes	543	284	259	178	106	110	149
Model chi-square	390.7	279.7	168.6	221.6	109.5	111.6	132.2
Log likelihood	-2435	-1221	-1190	-739	-456.5	-491.5	-681
LR tests			47.55**	2 vs 2a,2b	51.62**	3 vs 3a,3b	39.89

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year and industry dummies.

Table 4-A 10 Hazard model: only subsidiaries with at least 25% ownership

	Full sample	Integrated Industries	Non-Integrated Industries	Integrated Industries		Non-Integrated Industries	
				Efficiency	Localization	Efficiency	Localization
VARIABLES	Model 1	Model 2	Model 3	Model 2a	Model 2b	Model 3a	Model 3b
Labor costs	0.194**	0.306***	0.065	0.413***	0.203	-0.028	0.174
	(0.076)	(0.098)	(0.120)	(0.136)	(0.142)	(0.210)	(0.156)
Country growth	-0.087***	-0.065*	-0.100***	-0.043	-0.107*	-0.057	-0.138**
	(0.025)	(0.036)	(0.036)	(0.044)	(0.062)	(0.048)	(0.054)
Jp agglomeration	-0.194***	-0.231***	-0.112	-0.219**	-0.231**	-0.041	-0.133
	(0.057)	(0.078)	(0.086)	(0.109)	(0.116)	(0.156)	(0.105)
RCA	0.086	0.092	0.160	0.026	0.071	0.346	0.041
	(0.110)	(0.152)	(0.165)	(0.214)	(0.226)	(0.300)	(0.220)
Country uncertainty	-2.681**	-4.012***	-0.846	-3.675**	-5.810**	-0.358	-0.985
	(1.073)	(1.431)	(1.490)	(1.791)	(2.820)	(2.105)	(1.995)
Country risk	0.170	0.106	0.400	-0.049	0.169	1.110*	-0.062
	(0.306)	(0.431)	(0.459)	(0.529)	(0.775)	(0.636)	(0.683)
Affiliate age	0.079***	0.058**	0.097***	0.067*	0.053	0.147***	0.058
	(0.021)	(0.029)	(0.029)	(0.038)	(0.051)	(0.053)	(0.037)
Affiliate age sqr	-0.002***	-0.002**	-0.002**	-0.002	-0.002	-0.003*	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Minority owned	0.352***	0.441***	0.269*	0.473**	0.469*	0.355	0.222
	(0.107)	(0.148)	(0.163)	(0.184)	(0.262)	(0.255)	(0.219)
Affiliate size	-0.333***	-0.328***	-0.330***	-0.392***	-0.223**	-0.405***	-0.296***
	(0.038)	(0.054)	(0.055)	(0.064)	(0.098)	(0.092)	(0.067)
Unique affiliate	-0.507***	-0.256	-0.750***	-0.473**	0.155	-0.617**	-0.809***
	(0.119)	(0.169)	(0.170)	(0.224)	(0.269)	(0.243)	(0.243)
Sale co-location	0.312**	0.316*	0.324*	0.295	0.363	0.361	0.314
	(0.133)	(0.183)	(0.196)	(0.247)	(0.261)	(0.305)	(0.263)
RD co-location	0.324	0.521**	-0.898	0.770**	-0.065	-0.840	-0.906
	(0.221)	(0.263)	(0.660)	(0.338)	(0.529)	(1.104)	(0.853)
HQ co-location	-0.133	-0.157	-0.148	-0.439	0.326	-0.376	-0.094
	(0.205)	(0.259)	(0.372)	(0.325)	(0.437)	(0.763)	(0.456)
Firm experience	-0.003	-0.004	-0.005	0.013	-0.033**	-0.001	-0.006
	(0.006)	(0.008)	(0.009)	(0.011)	(0.014)	(0.015)	(0.012)
Firm diversification	-0.079*	-0.146***	0.009	-0.241***	0.157	-0.102	0.122
	(0.045)	(0.055)	(0.084)	(0.064)	(0.113)	(0.139)	(0.125)
Firm ROA	-6.971***	-4.718**	-9.856***	-5.286**	-4.056	-4.596	-11.210***
	(1.615)	(1.978)	(2.729)	(2.403)	(3.530)	(5.500)	(2.995)
Firm RI	0.315	-0.639	1.533	-0.442	0.451	-0.307	2.455*
	(0.736)	(0.984)	(1.087)	(1.676)	(1.305)	(2.103)	(1.265)
Firm size	0.049	0.133*	-0.030	0.087	0.208	0.050	-0.033
	(0.050)	(0.071)	(0.073)	(0.093)	(0.130)	(0.112)	(0.103)
Industry contraction	-0.003	0.154	0.027	-0.133	0.458	0.287	-0.172
	(0.127)	(0.189)	(0.171)	(0.264)	(0.292)	(0.264)	(0.236)
Constant	-2.304**	-3.806**	-1.449	-3.541	-4.677*	-3.782*	-1.483
	(1.045)	(1.659)	(1.541)	(2.287)	(2.636)	(2.224)	(2.263)
Observations	22,890	11,271	11,619	6,726	4,545	4,599	7,020
Nonzero outcomes	459	254	205	159	95	85	120
Model chi-square	365.4	277.2	166.9	211.7	124.1	114.7	127.4
Log likelihood	-2086	-1094	-962.6	-661.3	-409.1	-387.7	-557
LR tests		1 vs 2,3	57.88***	2 vs 2a,2b	47.81*	3 vs 3a,3b	38.95

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year and industry dummies.

Table 4-A 11 Hazard model: interaction of labor cost with local demand levels.

	Full sample	Integrated Industries	Non-Integrated Industries	Integrated Industries		Non-Integrated Industries	
				Efficiency	Localization	Efficiency	Localization
VARIABLES	Model 1	Model 2	Model 3	Model 2a	Model 2b	Model 3a	Model 3b
Labor costs	0.219***	0.348***	0.101	0.516***	0.163	0.001	0.204
	(0.073)	(0.098)	(0.111)	(0.137)	(0.147)	(0.196)	(0.143)
GDP	0.080*	0.033	0.096	-0.047	0.239*	0.136	0.080
	(0.048)	(0.071)	(0.066)	(0.084)	(0.142)	(0.107)	(0.095)
Labor costs # GDP	-0.023	0.026	-0.104	0.086	-0.043	-0.127	-0.116
	(0.045)	(0.063)	(0.068)	(0.085)	(0.100)	(0.099)	(0.096)
Country growth	-0.090***	-0.058	-0.107***	-0.033	-0.080	-0.069	-0.151***
	(0.024)	(0.039)	(0.031)	(0.047)	(0.069)	(0.044)	(0.045)
Jp agglomeration	-0.194***	-0.212**	-0.122	-0.154	-0.312**	-0.070	-0.098
	(0.064)	(0.091)	(0.095)	(0.118)	(0.150)	(0.162)	(0.118)
RCA	0.105	0.091	0.170	0.023	0.109	0.289	0.061
	(0.101)	(0.152)	(0.144)	(0.216)	(0.220)	(0.236)	(0.197)
Country uncertainty	-1.611*	-3.117**	-0.236	-2.861*	-3.236	0.084	-0.551
	(0.888)	(1.336)	(1.171)	(1.675)	(2.243)	(1.811)	(1.552)
Country risk	0.168	0.091	0.266	-0.391	0.943	0.906	-0.205
	(0.295)	(0.456)	(0.399)	(0.569)	(0.888)	(0.567)	(0.563)
Affiliate age	0.083***	0.065**	0.099***	0.069**	0.058	0.129***	0.071**
	(0.018)	(0.026)	(0.026)	(0.035)	(0.045)	(0.048)	(0.032)
Affiliate age sqr	-0.002***	-0.002**	-0.002***	-0.002*	-0.002	-0.003**	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Minority owned	0.572***	0.603***	0.576***	0.704***	0.526**	0.683***	0.555***
	(0.093)	(0.129)	(0.136)	(0.165)	(0.218)	(0.207)	(0.184)
Affiliate size	-0.297***	-0.293***	-0.295***	-0.331***	-0.203**	-0.273***	-0.313***
	(0.036)	(0.053)	(0.051)	(0.063)	(0.093)	(0.091)	(0.062)
Unique affiliate	-0.431***	-0.293*	-0.587***	-0.506**	0.042	-0.596***	-0.546**
	(0.110)	(0.156)	(0.152)	(0.209)	(0.251)	(0.223)	(0.214)
Sale co-location	0.226*	0.212	0.227	0.098	0.305	0.157	0.262
	(0.121)	(0.172)	(0.179)	(0.229)	(0.247)	(0.269)	(0.240)
RD co-location	-0.056	-0.067	-0.173	-0.239	0.180	-0.404	-0.104
	(0.167)	(0.214)	(0.300)	(0.266)	(0.394)	(0.596)	(0.360)
HQ co-location	-0.002	-0.001	-0.006	0.015	-0.032**	0.008	-0.013
	(0.005)	(0.008)	(0.008)	(0.011)	(0.014)	(0.014)	(0.011)
Firm experience	-0.077*	-0.129**	-0.027	-0.219***	0.099	-0.131	0.045
	(0.042)	(0.054)	(0.067)	(0.064)	(0.108)	(0.115)	(0.093)
Firm diversification	-5.593***	-4.511**	-6.634**	-5.279**	-3.049	-2.514	-7.850***
	(1.533)	(1.872)	(2.678)	(2.289)	(3.470)	(4.994)	(3.003)
Firm ROA	0.409	-0.275	1.168	0.723	0.194	0.268	1.644
	(0.681)	(0.929)	(0.986)	(1.549)	(1.266)	(1.792)	(1.170)
Firm RI	0.078*	0.156**	0.011	0.121	0.263**	0.064	0.056
	(0.046)	(0.066)	(0.066)	(0.084)	(0.124)	(0.099)	(0.093)
Firm size	-0.009	0.230	-0.067	-0.119	0.685**	0.049	-0.133
	(0.114)	(0.172)	(0.152)	(0.238)	(0.269)	(0.226)	(0.210)
Industry contraction	-3.002***	-4.074***	-2.302*	-4.581**	-5.291**	-4.517**	-3.074
	(0.952)	(1.504)	(1.356)	(2.138)	(2.314)	(1.937)	(1.959)
Observations	24,769	11,947	12,822	7,053	4,894	5,052	7,770
Nonzero outcomes	545	285	260	179	106	110	150
Model chi-square	398.6	279.4	171.7	204.6	117.4	120.4	130.9
Log likelihood	-2441	-1225	-1193	-742.6	-455.4	-492.8	-684.7
LR test		1 vs 2,3	48.03**	2 vs 2a,2b	52.26**	3 vs 3a,3b	35.65

Clustered standard errors at the subsidiary level in parentheses*** p<0.01, ** p<0.05, * p<0.1. Regressions include year and industry dummies.

Chapter 5
General Conclusions

5.1 Summary of main findings

This dissertation explores the interplay between the MNE organization, the external local environment and subsidiary internal capabilities in influencing subsidiary's performance. Subsidiaries have the possibilities to access and integrate a bundle of heterogeneous resources from the internal network of the MNE and from the actors present in the local environment where the subsidiary operates. The MNE and the environment, however, do not only function as sources of resources, but may also put the subsidiary under operational pressure due to strategic restructuring at the organizational level (MNE) or unfavorable macro-economic conditions. Hence, the MNE and the local environment become two important factors shaping subsidiary activities. Over time subsidiaries are able to evolve and undertake R&D mandates to develop their own capabilities, becoming the third factor important for subsidiary evolution. The dissertation aims at expanding the understanding of these three factors in shaping subsidiary operations and performance outcomes. The thesis consists of three chapters, each one studying the impact of the MNE, the local environment and the subsidiary factors and their interrelation on a specific dimension of subsidiary performance. The first two chapters relate to the subsidiary process of knowledge creation and its economic application, while the last chapter focuses on subsidiary survival.

Chapter 2 explores the ability of MNE units to integrate existing technologies from multiple fields in previously unexplored ways by exploiting the diverse knowledge present within the MNE network. This study applies a newly developed patent indicator (Verhoeven et al, 2016) to measure the technological recombination novelty of a single inventions at the global level, thus taking as reference the population of (patented) inventions worldwide. The chapter empirically tests the assumed belief that MNEs, by virtue of their simultaneous presence in multiple locations, facilitate connection and integration of specialized knowledge across distant locations (Kogut & Zander, 1992). Existing intra-firm knowledge collaborations are used to define each unit network in terms of geographic spread and technological distance between collaborating units.

The findings presented in this chapter suggest an inverted U shaped relationship between the two knowledge network dimensions and unit novelty performance. Therefore, the idea that heterogeneous knowledge inputs originating from different geographical and technological origins stimulate the discovery of new ways of recombining knowledge is valid only up to a certain point. If the network grows too big, coordination costs may outweigh the benefits arising from getting access to diverse knowledge. Likewise, although technological distance increases variety, a complete lack of prior knowledge on the technologies developed by partners may prevent units from fully understand their functioning to identify possible ways to integrate them in new inventions. Further analysis at the technology field level confirms the important role of the MNE knowledge network (the MNE factor) in providing complementary expertise to the unit (the subsidiary factor). The results also show that the expertise situated in the intra-firm international network is more important than the expertise present in the local environment (the local factor).

Chapter 3 investigates when and to what extent subsidiary local R&D and R&D conducted abroad by the MNE improve subsidiary productivity. By using detailed information on R&D expenditures of foreign subsidiaries located in The Netherlands, the study shows the impact of the two types of R&D activity to depend on the relative knowledge sourcing opportunities present in the host country. The findings suggest that the productivity returns to local R&D investments (the subsidiary factor) are higher in industries where the host country (the local factor) is at the global frontier in terms of innovative activities, while the R&D conducted in the rest of the MNE network (the MNE factor) is most effective in improving subsidiary productivity when the host country industry R&D environment is lagging behind. Finally, the complementarity effect found for the two types of R&D in industries that are not at the frontier underscores the need for local R&D investments to absorb and apply effectively the advanced knowledge accessed from the MNE network.

Chapter 4 examines the host country conditions (the local factor) that affect subsidiary survival in the context of changing MNE international strategies (the MNE factor) and global markets integration. The study provides empirical insights relevant for the debate on the influence of industry forces and MNE strategic orientation on the propensity of subsidiary divestments. The results obtained by analyzing divestment decisions of Japanese foreign manufacturing subsidiaries suggest that the propensity to divest in high labor cost countries is more pronounced in globally integrated industries, while in not integrated industries subsidiary existence is dependent on the evolution of the local market. These divestment patterns become more

outspoken when MNEs align their strategic orientation to the global industry trends in market integration, i.e. a cost efficiency orientation in integrated industries vs a localization orientation in fragmented industries.

Overall, the empirical findings of this dissertation have contributed to a better understanding of the international and local dynamics behind the performance of subsidiary operations. The three factors identified at the beginning of this dissertation: MNE, local environment and subsidiary capabilities, have been shown, in heterogeneous forms, to contribute, directly and indirectly, to subsidiary operations and performance analyzed in each chapter. Chapter 2 has shown the positive role of the MNE internal knowledge network (the MNE factor) in stimulating (up to a point) local unit's novel recombination of knowledge originating from distant geographic locations (Phene & Almeida, 2008). This finding contributes to the discussion on the geographic distribution of R&D in MNEs and the mechanisms of knowledge integration across subsidiaries. A recent study of Berry (2018) found foreign subsidiaries that were embedded in the internal MNE's knowledge network to make more incremental and less radical innovations. Here I suggest that subsidiary's integration in MNE networks that offer enough technological diversity and are not excessively geographically dispersed can increase the potential to recombine knowledge in novel ways and create radical innovations. Chapter 3 has underlined how the technological strength of the local environment (the local factor) can reduce the effective contribution of the MNE factor to subsidiary productivity, thus qualifying the traditional view that considers MNEs capable of leveraging their home based knowledge in foreign markets (Hymer, 1976). At the same time, the local factor under these circumstances strengthens the role of subsidiary R&D capabilities in improving subsidiary operations (Berry, 2015). These results also speaks to the literature on optimal geographic organization of R&D activities across the MNE and how subsidiaries can benefit from R&D performed in different environments (Lahiri, 2010; Berry, 2015; Phene & Almeida, 2008). Moreover, Chapter 4 suggested another dimension of the interplay between factors when considering subsidiary survival. In Chapter 4 the MNE strategic orientation adopted by the MNE at global level affected the relevance of the local factors in provoking subsidiary divestment. Therefore, future work on subsidiary activities should integrate these three factors: MNE, local environment and subsidiary capabilities, in one framework.

5.2 Policy and managerial implications

Policy makers aiming to attract and maintain foreign firms operations in their countries should realize that the conditions of their market, and the effect of their local policies, may impact foreign subsidiary operations through the filter of the other two factors, MNE and subsidiary capabilities, that determine subsidiary evolution. Moreover, Chapter 3 and especially Chapter 4 suggest that global trends in the industry (Birkinshaw et al., 1995) are relevant factors to explain subsidiary activities. In Chapter 3, the industry global technological frontier was indirectly influencing the performance consequences of subsidiary R&D investments, while global industry trade integration in Chapter 4 was affecting the survival of foreign operations in host countries with high labor costs. Policy makers are advised to continuously monitor the conditions of the country innovation system in relation to the global frontier and international markets. Industrial policies aiming at closing the gap with the global frontier may increase subsidiary productivity through more effective use of local R&D. In high labor cost countries, this may help to reduce divestment pressure from trade integration. Moreover, Chapter 2 suggests that R&D performing subsidiaries can source and recombine local knowledge beyond their technological core domain. This process stimulates the discovery of novel innovations capable to push the technological frontier and increase social welfare. Policy makers should therefore also incentivize the creation of a diverse knowledge base in the regional innovation ecosystem by promoting active collaborations and joint R&D projects among actors with different technological profiles.

Similar implications can be drawn for subsidiaries and headquarter management. The findings suggests the need to monitor the evolution of the local environment in relation to the global industry to identify the most effective manufacturing configuration and knowledge sourcing strategy across the MNE network and the local environment. In regards to the local environment, R&D managers should try to expand their links with the local scientific and business community. Although location studies stress the importance of locating R&D investments in regions that match the technological specialization of the investment, Jacobian-type agglomeration economies may stimulate R&D performing subsidiaries to conduct more novel boundary-spanning technological search.

Second, the results found in both the first and the second study confirm the difficulties encountered by subsidiaries in successfully assimilating the knowledge held in other parts of the intra-firm network. Managers of units that want to overcome learning traps with boundary-spanning R&D projects, or that are simply located in technologically poor environments, may

choose to engage in joint work with other units of the MNE group in order to share expertise and acquire new knowledge. However, before starting a collaboration, managers of both units should carefully assess the technological fit with the potential partner to ensure a common technical understanding that guarantees a smooth exchange of knowledge, while leaving enough space for learning opportunities. Moreover, an excessive number of links maintained with multiple locations may overload the team with less relevant information that distracts them from identifying valuable knowledge. When it comes to discovering new recombinations, Chapter 2 suggests that the geographically distributed collaboration network was inefficiently 'overstretched' in almost half the cases. In this sense, managers who want to improve their chances to create novelty, should re-evaluate the technological synergies with all current partners and may also want to reduce their existing intra-firm network in order to concentrate their resources and attention only in the most promising ones.

In Chapter 3, when considering economic productivity of foreign subsidiaries, the observed share of MNE R&D over the total subsidiary R&D in subsidiaries that are active in industries behind the global technological frontier was still far below the optimal share estimated in our model. In that case, the MNE should seek to involve more the subsidiary in its knowledge creation process, and facilitate the setting up of R&D activities to support subsidiaries innovation and knowledge integration within the group. The returns to the MNE R&D are substantially higher than the ones to local R&D projects in industries that are behind the frontier. However, managers of subsidiaries that are dependent on the R&D of their MNE group, should maintain investments in their local R&D facilities to possess the necessary instruments to learn and apply the MNE technologies.

5.3 Limitations and directions for further research

While these studies provide interesting insights, I recognize in each study several important limitations that open up possibilities for future research.

First, **Chapter 2** has the limitation to rely on patents as a proxy for innovation. Patents cover only a fraction of total innovation created and certain sectors tend to be over represented. Nevertheless, they have the advantage to incorporate a broad set of information that allow for large scale analysis to uncover important technological patterns. Second, the regional environment is only measured in terms of technological strength and diversity. Future research might create unit's regional knowledge network similar to the one constructed for the intra-firm

knowledge network, by looking at collaborations with local external partners. Third, the patent indicator used in the analysis to identify novel recombinations does not consider the distance in the technological space of the two components recombined. In the sensitivity test I experiment with an alternative continuous measure of unconventionality that partially addresses this limitation an interesting option would be to measure novelty using text-based indicators on the patent document rather than relying on technological classifications (Art et al., 2018). Further, research could apply network theory to investigate other network characteristics, (e.g. centrality, density) in the context of intra-firm R&D units collaborations and technological novelty. Finally, the development of highly novel inventions that depart from the existing paradigms may also affect the future role that the subsidiary will have in the MNE's knowledge network by increasing its technological relevance in the MNE group. Further research could look at the impact that these discoveries have on the role of subsidiaries as global innovators in the MNE group.

An important limitation of **Chapter 3** is the lack of information about geographic location of the parent MNE. Which does not allow to consider the relative technological strength of the two local environments. Patent data, although with the limitations described before, would add information about the technological type and scope of the R&D investments of subsidiaries, but would require access to the micro data beyond the anonymized version that I had available. Further research may integrate the frameworks of Chapter 1 and Chapter 2 to estimate a) the effect of local vs MNE R&D on novelty success, b) the effect of technological novelty on productivity. This would be important, as most of innovation literature is limited to technological impact without looking at the economic effect.

In **Chapter 4** only country-level factors are considered in the analysis. Nevertheless, location studies (Alcacer & Chung, 2007; Belderbos & Somers, 2015) have emphasized the relevant subnational heterogeneity in the distribution of technological clusters, economic agglomeration factors and costs developments which can influence the activities and functions of subsidiaries. For instance, the access to specialized suppliers in regions with high agglomeration economies may allow subsidiaries to continue operating under high labor costs pressure at the country level. Further research could explore this additional level of analysis. Finally, the study uses a measure for MNCs' strategic orientation derived from stated investment purposes of their foreign manufacturing subsidiaries. Future research may seek to capture the MNE strategic objectives and global positioning with detailed surveys at the group level.

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