ORIGINS OF KNOWLEDGE CREATION AND MULTINATIONAL FIRM PERFORMANCE

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The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

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ABSTRACT

Knowledge creation is one of the most important instruments of firm survival and growth (Grant, 1996; Kogut and Zander, 1992; Kogut and Zander, 1993). Firms make decisions on whether to create knowledge using single country or international strategies, individually or in collaboration with various internal and external partners such as units, universities or research centres, which may operate in different countries (Arora et al., 2014; Berry, 2014; He and Wong, 2004; Kogut and Zander, 1992; Kogut and Zander, 1993; Van de Vrande, 2013). Therefore, firms make strategic choices regarding the locational and organisational origins of knowledge creation. Despite a growing body of research suggesting that firms increasingly create knowledge using international, multi-country strategies (Berry, 2014; Patel et al., 2014; Van de Vrande, 2013), many aspects of these strategies remain unclear. Using insights from knowledge of the firm and subsidiary evolution theory as well as interrelated theories, this thesis aims to show the value of different international knowledge creation strategies, how firms combine them in their overall knowledge strategy and align them to different contexts in which they operate. Based on a sample of 46,712 patents as indicators of knowledge creation granted to 150 UK headquartered manufacturing sector multinational firms and their 5,352 first level subsidiaries during the 2003 to 2012 period, the findings show that international internal and external knowledge creation strategies have a U-shaped relationship with performance. Also, this thesis offers evidence that multinational firms need to combine single country and international as well as internal and external international knowledge creation strategies in a balanced way in their overall strategy. Finally, these effects depend significantly on the characteristics of the environment in which multinational firms operate.

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CHAPTER I

INTRODUCTION

1. RESEARCH BACKGROUND

Knowledge creation is one of the principal elements of economic growth in modern firms and societies (Almeida, 1996; Almeida et al., 2002; Belderbos et al., 2013; Buckley and Carter, 1999; Florida, 1997; Kogut and Zander, 1993; Kurokawa et al., 2007; Murray et al., 1995; Patel et al., 2014) and among the most important resources of the firm (Grant, 1996). Due to increasing global competition and decreasing product life cycles, building and retaining competitive advantage for firms depends upon their ability to continuously create valuable knowledge (Artz et al., 2010; Patel et al., 2014).

We define knowledge creation strategy as a set of choices firms make regarding whether the knowledge is created using single country or international strategies, which represent the locational origins of knowledge creation, and whether the knowledge is created with internal partners (operating within the firm) or with external partners (operating outside the firm), which represent the organisational origins of knowledge creation (Berry, 2014; He and Wong, 2004). In this thesis we consider a specific type of knowledge creation, technical knowledge, which we measure by firm patents.

Firms can create knowledge in various ways, ranging from individual unit and single country knowledge to international knowledge creation involving various internal and external partners such as units, universities, research centres and various other stakeholders which may operate in different countries (Arora et al., 2014; Berry, 2014; Kogut and Zander, 1992; Kogut and Zander, 1993; Van de Vrande, 2013). We focus on international knowledge creation whose main feature is its multi-country, collaborative nature (Berry, 2014). This knowledge creation strategy is an outcome of the development of markets for technology, which increases the strategic space for innovation and represents the new frontier in knowledge creation (Ambos, 2005; Arora et al., 2001).

Firms increasingly create knowledge using international strategies, which is an indication that the locational and organisational origins of knowledge creation are changing (Florida, 1997). The traditional single firm and single country model of knowledge creation is being substituted by international knowledge creation in which firms cooperate with partners from at least two different countries in order to secure access to valuable scientific and technical knowledge and to reduce the costs and risks of creating knowledge and retaining leadership in a particular

technological domain (Berry, 2014; Cassiman and Veugelers, 2006; Chesbrough, 2006; Kogut and Zander, 1993; Narula and Hagedoorn, 1999).

Multinational enterprises (MNEs) are at the forefront of this trend and as such the subject of this thesis. They use the idiosyncratic positions based on the countries in which they operate to build a global knowledge creation network which in return gives them unique knowledge creation opportunities (Ahuja and Katila, 2004; Almeida, 1996; Feinberg and Gupta, 2004; Gupta and Govindarajan, 2000; Pearce, 1999). By having subsidiaries which operate in various countries simultaneously, MNEs are able to exploit differences in knowledge reservoirs across countries and create knowledge using more complex, international knowledge creation strategies (Birkinshaw and Hood, 1998; Buckley and Carter, 1999; Ghoshal and Bartlett, 1990; Kafouros et al., 2012).

Firms are also increasingly creating knowledge using combinations of various knowledge creation strategies. They are replacing the specialisation based knowledge creation model where knowledge is created only by using one strategy with knowledge creation models which rely on a combination of different strategies in order to capitalise on the different benefits each of the knowledge creation strategies bring, with the ultimate goal to increase their knowledge creation capabilities and to keep up with the demand for new breakthroughs in their technological field (Birkinshaw and Hood, 1998; Kogut and Zander, 1993; March, 1991). However, firms differ in the way they combine knowledge creation strategies. They can combine strategies by either prioritising or balancing between them. In other words, they can simultaneously allocate their efforts and resources among different knowledge creation strategies in a balanced way or they can engage in different strategies in such a way that one or a few strategies have a dominating role (March, 1991). For instance, some firms may focus on different single country knowledge creation strategies such as individual unit knowledge or they collaborate with domestic partners. In contrast, other firms may create knowledge using a combination of different international strategies by collaborating with other units or partners operating in different countries. Finally, some firms may combine all knowledge creation strategies.

The outcome of these trends is substantial growth of international knowledge creation within the firm's overall knowledge creation strategy. Studies argue that the main advantage of creating knowledge using international strategies is that they give access to a plethora of novel and heterogeneous information, especially important in conditions of uncertainty where the diversity of available know how provides a stronger knowledge base and more robust ground for learning (Birkinshaw and Hood, 1998; Cohen and Levinthal, 1990; Kogut and Zander, 1992; Kogut and Zander, 1993; March, 1991; West and Bogers, 2013; Yamin and Otto, 2004).

Moreover, researchers argue that international knowledge is the only path to developing high value innovations and sustaining competitiveness (Almeida, 1996; Patel et al., 2014; Pearce, 1999). Also, MNEs create knowledge internationally because their internal research efforts are combined with knowledge of their partners allowing them to lower fixed research costs related to technological advancement (Chung and Yeaple, 2008). However, other studies emphasise potential limitations of international knowledge creation strategies. They argue that the many benefits may be reduced by certain hazards and risks primarily related to increased complexity and governance costs of managing an extensive, over globalised network for knowledge creation (Belderbos et al., 2010; Kotabe et al., 2007; Leiponen and Helfat, 2010; March, 1991). Furthermore, international knowledge creation, as opposed to single unit and single country knowledge creation, makes it challenging to ensure coherence of operations, control and coordination of intellectual property and makes valuable knowledge assets difficult to protect from the risk of diffusion (Pearce, 1999).

The aforementioned significance and trends in international knowledge creation and these contradictory views call for further clarification and a more detailed inquiry into the phenomenon of international knowledge creation and the value it represents for the firm.

2. RESEARCH GAP

Two distinct research avenues can be identified within the current conversation regarding knowledge creation strategies in the literature. Firstly, research analysing the performance effects of knowledge creation with different locational and organisational origins is incomplete. Although the literature acknowledged the different ways of creating knowledge, little has been said about the specific value of different international knowledge creation strategies in particular. What we do not know is the exact performance impact of international internal and external knowledge creation. Secondly, our understanding of how firms combine and allocate resources between different knowledge creation strategies, in particular international knowledge creation strategies, and the related effects on performance is limited. What we do not know is whether differences in MNE performance can be explained by the different ways in which firms combine different knowledge creation strategies.

Prior studies acknowledged that firms may create knowledge in different ways. Still, they differentiate knowledge creation strategies by looking at one factor at a time. For instance, studies gave insight into the locational origins of knowledge creation by analysing whether the firm should create knowledge using single country or international strategies (Frost, 2001; Patel et al., 2014; Spencer, 2003), what is the performance effect of each of these strategies (Kogut and Zander, 1992; Kogut and Zander, 1993; Singh, 2008) and which factors motivate

and facilitate international knowledge creation (Berry, 2014). Studies also addressed the organisational origins by examining whether firms should use internal or external strategies and their impacts on performance (Alcácer and Zhao, 2012; Kogut and Zander, 1992; Kogut and Zander, 1993; Yamin and Otto, 2004). These studies make the assumption that all knowledge creation that is international has the same performance effects or that for instance, the value of external knowledge is determined regardless of whether it is created in a single country or internationally. However, international knowledge creation may be scrutinised further into different international knowledge creation strategies which may have specific performance effects. Categorising international knowledge creation according to its organisational origins allows for the distinction between international knowledge created internally (within the MNE, with other units) or externally (beyond the MNE, with other partners). These different international knowledge creation strategies may have a specific performance effect, which was not fully studied by prior literature, to the best of our knowledge.

Particular studies refer to the lack of insight into international knowledge in particular. They argue that evidence on different international, multi-country knowledge and their related values are scarce (Kotabe et al., 2007; Phene and Almeida, 2008) and stocks of international knowledge remain as the missing link between sources and flows of knowledge (Foss and Pedersen, 2004). In fact, the literature addresses international knowledge more from the knowledge source and flow aspect rather than the knowledge creation aspect. What is known is the ways in which international knowledge for instance from the host country (where the units operate) (Almeida, 1996; Kotabe et al., 2007; Lahiri, 2010) or from external partners located in various countries (Ahuja and Katila, 2004; Kafouros et al., 2008; Katila and Ahuja, 2002; Luo and Peng, 1999) can be useful for the MNE as a source and flow, but the performance effect of different international knowledge creation strategies has largely been overlooked.

Moreover, the concept of international knowledge creation itself has changed in the literature. Traditionally, knowledge was considered as international when it was created outside the home country of the MNE group (Almeida, 1996; Kotabe et al., 2007; Lahiri, 2010), whereas most recent studies look at international knowledge creation in a different way, as being created in multi-country co-operative environments (Berry, 2014). This contributes to the argument that the phenomenon of international knowledge creation as multi-country knowledge is under-researched. In conclusion, the scarcity of studies giving more comprehensive views of different international knowledge creation strategies and their related values represents an opportunity for novel theoretical and empirical contributions, which

would help advance the discussion on benefits of different international knowledge creation strategies.

Secondly, since MNEs may create knowledge in different ways they face the challenge of how to allocate scarce inputs between them to maximise performance outputs (Bogers and West, 2012; March, 1991). In fact, one of the main decisions of corporate strategy is how many resources to devote to different strategies of knowledge creation and in which way (Birkinshaw and Hood, 1998; He and Wong, 2004; Nicholls‐Nixon and Woo, 2003; Van de Vrande, 2013). The pressure to make trade-offs between the different ways in which to create knowledge brings a degree of conflict in the firm's overall knowledge creation strategy (Gibson and Birkinshaw, 2004; Tushman and O'Reilly III, 1996). Researchers argue that current advances on the topic of knowledge creation are limited as many studies do not consider the value of simultaneously pursuing different knowledge creation strategies (Stettner et al., 2014). What we do not fully know is how firms distribute resources between different knowledge creation strategies, international knowledge creation strategies in particular, and how these different choices affect performance.

Firms, when making knowledge creation choices, may either opt to prioritise and devote more resources to specific strategies or try to achieve a balance between them. Some researchers argue that different knowledge creation strategies should be simultaneously pursued because they may contribute to the firm's performance in distinct ways and build the firm's ability to create valuable knowledge in the future (He and Wong, 2004; March, 1991; Raisch et al., 2009; Stettner et al., 2014; Tushman and O'Reilly III, 1996). However, there are also arguments which call for caution. Different knowledge strategies are rivals for firm's resources, they may create instabilities and tensions and they require different support systems, which involve specific costs (Andriopoulos and Lewis, 2009; He and Wong, 2004; Stettner et al., 2014; Tushman and O'Reilly III, 1996). These mixed views show that the effects of combining different knowledge creation strategies in different ways should be scrutinised further in order to determine their exact benefits. Therefore, what we know is that the effects of combining different knowledge strategies may be complex, but these impacts are not fully researched in case of different international knowledge creation strategies.

Building on the research gaps discussed above, the main focus of this thesis is the concept of international knowledge creation within MNEs. We examine the performance value of two different strategies of international knowledge creation, internal and external, discussed in detail in the third chapter. Additionally, we analyse whether combining these strategies for knowledge creation in different ways is significant for MNE group performance. Following prior studies, we define the concept of international knowledge creation as multi-country knowledge created between partners from at least two different countries (Berry, 2014; Yamin

and Otto, 2004). Furthermore, based on the organisational origins, we distinguish between two strategies of international knowledge creation: internal, which refers to knowledge created between two or more units within a MNE, and external, which involves cooperating with partners outside the organisation.

In order to develop hypotheses to address these gaps, we draw arguments from the knowledge of the firm and multinational subsidiary evolution theory and other interrelated theories, which are discussed in detail in the second chapter. By examining the performance effect of different international knowledge creation strategies, we advance the conversation related to the value of different strategies of knowledge creation for the MNE. Also, using the theories mentioned and empirical evidence offered by recent studies which looked at how firms distribute resources between different knowledge strategies (He and Wong, 2004; Nicholls‐Nixon and Woo, 2003; Patel et al., 2014; Stettner and Lavie, 2014; Van de Vrande, 2013), we analyse how firms combine different international knowledge creation strategies specifically and examine the effects of these combinations on performance of the group, with the ultimate goal of showing whether differences in performance can be explained by different knowledge creation combinations.

Our approach differs from prior studies as we analyse the performance effect of knowledge creation strategies based on different locational and organisational origins simultaneously. As mentioned, previous studies either focused on the locational origins and analysed international knowledge as opposed to single country knowledge (Alnuaimi et al., 2012; Berry, 2014; Patel et al., 2014) or distinguished between external and internal knowledge, but did not consider the locational origin at the same time (Arora et al., 2014; Frost and Zhou, 2005). Furthermore, this study aims to explore the performance effect of different international knowledge creation strategies on group level, which differs from studies examining unit or project level impacts (Alnuaimi et al., 2012; Kotabe et al., 2007; Singh, 2008). Also, we conceptualise and measure international knowledge creation strategies as multi-country knowledge (Berry, 2014), which follows most recent definitions and can be distinguished from studies, which looked at international knowledge as all knowledge outside the focal unit or country of operation (Almeida, 1996; Lahiri, 2010; Leiponen and Helfat, 2010; Rothaermel and Alexandre, 2009).

To analyse the hypotheses, this study uses econometric methods based on MNE group level data for 150 multinationals headquartered in the UK and their 5,352 units operating in various countries in the 2003 to 2012 period. The knowledge creation strategies are analysed based on 46,712 patents developed by the units and headquarters in the sample. We find evidence that both strategies of international knowledge creation have a U-shaped effect on MNE performance, consistent with other studies reporting the complex relationship between international knowledge in general and firm performance (Belderbos et al., 2010; Kotabe et

al., 2007). By showing that firms need to reach a certain point of internal and external international knowledge creation in order for the performance benefits to materialise, we reconcile previous mixed assumptions about their value. Also, we find that balancing rather than prioritising between single country and international knowledge creation is beneficial for group performance, as is balancing between different international knowledge creation strategies. Finally, we test if these effects are contingent on the environment in which the firm operates in. We find that the benefits of different international knowledge creation strategies and the ways in which they are combined within the MNE's overall knowledge creation strategy are moderated by instability in the environment.

3. RESEARCH QUESTIONS

As mentioned in the sections above, this research focuses on investigating the relationship between different strategies of international knowledge creation and performance. Following the discussion on what is not known in the literature regarding knowledge creation strategies in MNEs, the first research question in this thesis is:

1. *How do different international knowledge creation strategies affect MNE performance?*

As explained above, knowledge creation in the MNE can be of different origin. This thesis looks at knowledge based on the locational and organisational origins and investigates the value of two different international knowledge creation strategies: internal and external. We aim to show that differences in performance between firms can be attributed specifically to differences in levels of international internal and external knowledge creation. We expect that two firms with different levels of international knowledge creation strategies will experience dissimilar performance. This argument is based on knowledge of the firm and subsidiary evolution theory supported by theory of interconnected firms, all of which suggest that firms may derive specific value and develop their capabilities based on internal as well as external international knowledge creation strategies (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993; Lavie, 2006; Teece, 2007; Teece et al., 1997).

Prior knowledge literature offers largely mixed evidence when discussing the relationship between international knowledge and performance, which is discussed in detail in the fourth chapter of this thesis. For instance, some authors argue that MNEs generate difficult to replicate competitive advantages by combining knowledge from various country locations and they are able to benefit from the diversity of new ideas and processes that international knowledge brings to the firm (Almeida, 1996; Frost, 2001; Gupta and Govindarajan, 2000; Patel et al., 2014). On the other hand, the literature argues that difficult to manage relationships

between partners in international knowledge creation make the process challenging (Szulanski, 1996). Also, a variety of different knowledge from international locations can create inefficiencies and duplication of ideas on group level (Berry, 2014). By scrutinising international knowledge creation further into internal and external, international knowledge creation might bring more specific conclusions about this relationship, which is the aim of this research question. It is analysed in the fourth chapter.

In order to answer this and subsequent research questions, the thesis applies panel data modelling. Using system generalised method of moments (system GMM) as one of the main methods recommended for panel data analysis, it estimates a production function model, which relates output with the inputs of capital and labour and with knowledge based indicators and controls, which was extensively used in prior studies (Griliches, 1998b; Hall and Mairesse, 1995; Temouri et al., 2008). Apart from the production method, this research uses other established indicators of performance to check for the robustness of the main results. As mentioned, the analysis is based on 46,712 patents granted to 150 MNEs and their subsidiaries as indicators of specific knowledge creation strategies.

The second research question, which builds on the first, is:

2. *Do MNEs which combine different international knowledge creation strategies in a more balanced way achieve higher performance compared to MNEs which prioritise between them?*

As mentioned in previous section, recent studies argue that firms which simultaneously pursue different knowledge strategies are able to achieve higher performance compared to firms which implement just one particular strategy or prioritise between them. This argument is based on knowledge of the firm and subsidiary evolution theory supported by insights from portfolio theory, which suggest that there is competition within firms for knowledge resources to be distributed among different strategies (Birkinshaw and Hood, 1998) and that firms will combine different knowledge creation strategies simultaneously to ensure that they have multiple options and ideas to choose from (March, 1991) useful in conditions of uncertainty (McGrath, 1997; Nelson, 1961; Vassolo et al., 2004).

Because resources for knowledge creation are limited and because different strategies of knowledge creation all have their merits and limits with regards to performance (discussed in detail in the fourth and fifth chapter), firms will try to employ the most efficient combination of knowledge creation strategies, which will give them the best outcome. Two firms may apply both strategies of international knowledge creation, but the performance effect will be contingent upon the ways in which they combine them. Particular firms may opt for one

dominating international knowledge creation strategy, whereas others may apply both relatively equally. This question therefore analyses the performance value of combining different knowledge creation strategies based on their locational and organisational origins, which, to our knowledge, has not been tested in the literature in this context. The fifth chapter addresses this particular research question.

The third research question is:

3. *How does the environment in which the MNEs operate affect the relationship between international knowledge creation strategies and MNE performance?*

The first research question assumes that what matters for performance is whether and to what extent MNEs apply different international knowledge creation strategies. The second question argues that performance depends on how MNEs combine different international knowledge creation strategies. However, knowledge based theory and subsidiary evolution also argue that the relationship between international knowledge creation and performance may be conditioned by the environment in which the firm operates (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). In other words, MNEs with similar levels of international knowledge creation combined in similar way in their overall knowledge creation strategy may experience different performance outcomes contingent on the environment in which they operate. The theory argues that different environments have specific constraints such as speed of change, availability of information and uncertainty, which will influence and determine both the value of international knowledge creation strategies and how MNEs combine them (Birkinshaw and Hood, 1998; Dess and Beard, 1984; Keats and Hitt, 1988; Klevorick et al., 1995; Levinthal and March, 1993; Venkatraman, 1990). Therefore, particular strategies and combinations of international knowledge creation strategies might be more or less beneficial for firms operating in specific environments. This research question is addressed in the sixth chapter.

4. DEFINITIONS OF MAIN TERMS AND RESEARCH CONTEXT

4.1. The multinational enterprise (MNE)

This research studies knowledge creation and its performance implications in multinational enterprises specifically. The *multinational firm or enterprise (MNE)* is defined in the literature as an entity which engages in foreign direct investment (FDI) activity during which it acquires a controlling interest in a firm based in a foreign country or sets up a subsidiary in a foreign country (Markusen, 2004).

These firms are most suitable for researching different locational and organisational origins of knowledge creation for a few reasons. Firstly, multinational firms are global systems that combine advantages of various locations through their global network of subsidiaries (Buckley, 2009; Gupta and Govindarajan, 2000). International or multi-country knowledge, which is localised, constitutes one of these combined advantages (Almeida et al., 2002). Their global network of subsidiaries enables them to engage in international knowledge creation strategies, which may include collaborating with other units or partners operating in different countries (Gupta and Govindarajan, 2000).

Furthermore, theory suggests that MNEs are in a unique position to build their competitive advantages by combining knowledge based resources from various locations with the most suitable existing capabilities in the MNE and transferring different advantages such as knowledge across borders within their network of units, which is difficult to replicate for other firms (Berry, 2014; Kogut and Zander, 1992; Kogut and Zander, 1993; Martin and Salomon, 2003). Therefore, MNEs will engage in international, multi-country knowledge creation strategies. These complex knowledge creation processes result with developing a varied set of knowledge creation assets, which bring together ideas from different countries, whereas domestic firms for instance are limited since they operate in a more restricted, single country environment (Kogut and Zander, 1992; Kogut and Zander, 1993). In this view, MNEs are the ideal firm setting for researching different strategies of knowledge creation, which originate in different locations and organisational environments.

4.2. Knowledge creation strategy

The second main concept used in this research is knowledge creation strategy. We define *knowledge creation strategy* as the set of choices firms make with respect to the locational and organisational origins of creating knowledge (Berry, 2014).

According to the location, firms make choices whether knowledge will be created in a single country or internationally. *Single country knowledge creation* strategy refers to knowledge created in one country, which is the traditional model of knowledge creation in international business (IB) literature. The concept of *international knowledge creation* strategy, following prior studies, is defined as multi-country knowledge created between partners from at least two different countries (Berry, 2014; Yamin and Otto, 2004). The outcome of these strategies is knowledge creation, which brings together diverse knowledge advantages from different locations (Berry, 2014).

Firms also make choices regarding the organisational origins of knowledge creation. There are two main types of knowledge creation strategies, internal and external (Belderbos et al., 2010; Szulanski, 1996). *Internal knowledge creation* strategy refers to the cases in which firms choose to create knowledge between two or more units within the MNE network operating in the same or different countries. *External knowledge creation* strategy refers to the cases in which firms choose to create knowledge between one (or more) units and at least one external partner (outside the MNE network) operating in the same or different country. These different knowledge creation strategies are discussed in detail in the third chapter.

Knowledge creation in general refers to relatively observable and tangible outputs of a creative process such as innovations, operating rules, manufacturing technologies, as well as intangible outputs such as ideas and know-how (Kogut and Zander, 1992). The creative process based on which knowledge is created can be a new idea or innovation, a recombination of old ideas, a scheme that challenges the present concept, a formula, or a different approach (Van de Ven, 1986). It refers to the process during which the organization both recognises and creates problems and proactively creates new knowledge as a response and solution to these challenges (Nonaka, 1994). It is an outcome of interaction between tacit (knowledge that is difficult to communicate and held by individuals) and explicit (codified knowledge that is easily transmittable) knowledge (Nonaka, 1994).

Specifically, MNE knowledge creation refers to the knowledge outputs or the outcome of the creative process of innovation development in a multinational firm. Any organization needs not only to process inbound information efficiently but also to create new knowledge (Kogut and Zander, 1992; Kogut and Zander, 1993; Nonaka, 1994). Knowledge in the MNE has a dynamic nature which means that knowledge created by one unit or part of the organization can be transferred and generate a surge of related knowledge creation processes across the organisation, which sets off further innovations and also modifies the organization's wider knowledge system and affects its future knowledge creation potential (Kogut and Zander, 1992; Kogut and Zander, 1993; Nonaka, 1994) This represents the primary mechanism through which knowledge created by units of the MNE can affect performance on the group level.

Knowledge creation of focus in this thesis is technical knowledge specifically, which is evidenced by patents. Patents represent technological advances in a specific field, which can be either minor improvements or significant changes (Arora et al., 2014; Griliches, 1998b). Section 4 of the fourth chapter discusses the validity of patents as indicators of knowledge creation in detail.

4.2.1. Measuring knowledge creation strategy

Knowledge creation strategies can be measured in various ways where two of the most common indicators are research and development (R&D) investments and firm patents. Apart from these, some studies also used subjective measures of knowledge creation based on views of managers, obtained through surveys and interviews.

Many prior studies used R&D information, its levels, locational and organisational distribution as a proxy to account for the allocation and therefore the strategies firms use to create knowledge (Audretsch and Feldman, 1996; Lahiri, 2010). However, the distribution of R&D in units within the MNE network only gives limited information about knowledge creation strategies. Although using R&D information enables conclusions regarding which units create more knowledge than others, it is difficult to know whether the knowledge was created individually or with a partner which can belong to a different unit or an external organisation. By not knowing whether knowledge was created individually or with a partner it is not possible to determine with certainty whether it was created in a single country or internationally. Hence, R&D investments were not a measure suitable for the purpose of this research.

Patents, on the other hand, contain specific information about the knowledge creation strategy used to create the specific patent and were emphasised in prior literature as a suitable measure of innovativeness because they represent the net accretion of economically valuable knowledge (Arora et al., 2014; Griliches, 1998b). By using patent assignment information it is possible to identify the name of the individual units and partners creating a specific patent and the location in which they operate, which can be used to analyse the knowledge creation strategy used (Arora et al., 2014). For these reasons, patents and their accompanying information are used as proxies for knowledge creation strategy, following prior studies (Arora et al., 2014).

Patent is defined as a legal document issued by an authorized governmental agency, which gives the holder the right to utilise the innovation which is the subject of the patent for a specific time period (Griliches, 1998b). Since the patent documents contain information about the individuals or firms the patent is assigned to and their country of origin, we can, as mentioned, study the specific strategy used to create that knowledge (Arora et al., 2014).

However, patents as a measure have certain limitations. Three main limitations were emphasised by prior literature. Firstly, they do not account for all knowledge created by firms because not all innovations are patented (Griliches, 1998b). Secondly, they differ according

to their technical significance and economic utility, which implies that some patents may affect performance of the firm differently than others (Griliches, 1998b). Finally, they may not accurately portray the knowledge creation strategy because not all knowledge creation collaborators are listed on the patent document (Arora et al., 2014; Griliches, 1998b). For instance, a patent might be assigned to the headquarters only, but it might be created jointly with researchers from another unit. A recent study addressed this last issue and analysed knowledge and the strategies used to create it through interviews in order to test the reliability of information given by patent documentation (Arora et al., 2014). The study showed that interview information corresponds to the information on patent documents and concluded that patent based analyses are reliable when patent documentation is used to derive data about the exact strategy applied to create the patent. This substantiates the approach used in this thesis. Specifics about the database used and the patent information where data was obtained from is discussed in detail in the fourth chapter. Also, the significance of patents as measures of knowledge creation, their applicability for this research, limitations and solutions adopted to minimise the limitations are addressed in the fourth chapter.

4.3. Multinational firm performance

Firm performance can be defined as a specific type of organisational effectiveness, a multi-dimensional construct which may include categories of firm outcome or success such as performance on the market, financial or operating indicators (Richard et al., 2009). Understanding performance and its elements is essential to a firm's survival and prosperity, especially in the era of globalisation characterised by intense competition, short product life cycles and success, which is based on knowledge creation. High firm performance is viewed as the ultimate goal of modern industrial activity (Richard et al., 2009).

Performance as a measure is used for evaluating specific firm strategies such as knowledge creation. Therefore, analysing the performance effects of knowledge creation strategies is the most appropriate way of evaluating the value of this particular type of firm strategy. Performance of the firm is a sub-construct of effectiveness and refers to various areas of firm outcomes: financial performance, product market performance, shareholder return (Richard et al., 2009), measures such as productivity indicators (Griliches, 1979; Griliches, 1998a; Hall and Mairesse, 1995), innovativeness (Ahuja and Katila, 2001) or subjective measures based on manager's perceptions (Gibson and Birkinshaw, 2004). The literature agrees that its main feature is methodological inconsistency and consequently, performance in studies is measured using multiple dimensions and heterogeneous approaches (Richard et al., 2009). This issue is addressed in more detail in the fourth chapter.

Performance in this research is measured as total factor productivity (TFP) of the whole MNE group. Previous studies established the productivity method as useful in studying knowledge related private returns on performance, especially in panel data environments (Hall and Mairesse, 1995). TFP is a parameter that modifies the relationship between capital, labour and output and has been traditionally identified with technological change, but it incorporates a variety of factors such as knowledge (Sargent and Rodriguez, 2001). To obtain this indicator, an established method in the literature was used, which focuses on developing a production function from which TFP levels for each firm can be estimated (Temouri et al., 2008). In this way, the potential productivity differences between firms can be identified, as well as the value of different strategies of knowledge creation as determinants of productivity. The method of obtaining this indicator and its advantages and disadvantages are described in detail in the fourth chapter.

Apart from this measure, this thesis relies on other indicators of performance. To control for the results given by TFP models, the effects of knowledge creation strategies were tested on three different measures of performance: labour productivity, represented by output per unit of labour, turnover (sales) and operating profit as financial measures of performance. Labour productivity is especially useful as a control for TFP in cases where there might be biases in constructing or reporting the capital or assets indicator, which is used in estimating TFP (Sargent and Rodriguez, 2001). Since labour productivity is estimated directly using output and labour inputs, these biases are to some extent mitigated. Finally, this measure is more effective than the TFP approach when analysing performance during a shorter time period (less than ten years) (Sargent and Rodriguez, 2001). The time period selected for this research is ten years, which makes the TFP indicator applicable, however, controlling for labour productivity will make the results more robust. The main results are also compared to turnover (sales) and operational profit indicators, to account for the financial aspect of firm performance.

4.4. Industry sector and country of focus

This study analyses knowledge creation strategies of manufacturing sector firms for a few reasons. Firstly, the rate of knowledge creation as well as the patterns used to create knowledge differs widely across industries (Kirner et al., 2009; Klevorick et al., 1995; Thornhill, 2006). For instance, technological advances in manufacturing industries such as computers and pharmaceuticals where new knowledge that changes the course of the field is consistently created differs significantly from knowledge created in services industries (Geerts et al., 2010). Service industry firms do not frequently engage in radical new knowledge creation and in general create less knowledge (Berry, 2014; Geerts et al., 2010). Firms in the service sector

mainly base their knowledge creation strategies on improving efficiency in delivery of their product (Geerts et al., 2010). In contrast, the manufacturing sector firms focus more on creating knowledge using inputs from a variety of locations outside of the firm boundaries in order to gather new ideas (Geerts et al., 2010). This process is important for manufacturing firms considering that they base their competitiveness on radical innovations and knowledge in general more than service firms (Geerts et al., 2010). Therefore, the performance value of knowledge creation may be higher in the manufacturing sector. Secondly, a recent study discussed differences between knowledge creation strategies in the services and manufacturing sector and concluded that manufacturing firms employ different knowledge creation strategies simultaneously, whereas service firms prefer to focus on specific strategies of knowledge creation (Geerts et al., 2010). Since the focus of this research is examining values of different complex strategies of knowledge creation, this research is based on a sample of manufacturing firms. In particular, we expect that this industry sector will engage in different strategies of international knowledge creation more than service sector firms. The specific sample for the analysis is discussed in more detail in the fourth chapter.

The analyses in this research are based on a sample of manufacturing MNEs headquartered in United Kingdom (UK). We expect that UK MNEs will specifically engage in different international knowledge creation strategies more than MNEs from other countries based on a few reasons. Firstly, UK MNEs are highly internationalised. As a single country, UK holds a significant 7.1 per cent of world outward FDI stock in 2013 and is ranked second following US, higher than other European countries such as Germany and France (UNCTAD, 2014a). Also, 16 UK MNEs are among the top non-financial MNEs ranked by foreign assets (UNCTAD, 2014a). Three of them (Vodafone Group PLC, Glaxosmithkline PLC and Astrazeneca PLC) are in the sample (Appendix 1). Furthermore, according to OECD, 45 per cent of scientific articles and 25 per cent of patent applications from UK were produced in international collaboration, which indicates the importance of international knowledge creation specifically in the country (OECD, 2012). The source also shows that UK has an above OECD median value of company patents filed at three major patent offices (European Patent Office, Japan Patent Office and United States Patent and Trademark Office) per GDP in 2012. This shows that UK firms engage extensively in knowledge creation and international knowledge creation in particular, which is suitable for the aims of this research.

It would be possible to focus on a sample of MNEs headquartered in other countries apart from the UK. However, since we aim to distinguish between knowledge created in different locations, in other words between single country and international knowledge, by taking into account MNEs headquartered in one country, we are better able to control for the single

country knowledge creation option. Moreover, OECD reports that UK firms engage strongly in knowledge creation (patenting) as well as universities and public labs whose number of patents filed per GDP are well above the OECD median (OECD, 2012). This means that UK represents a highly appealing option for single country knowledge creation which we take into account. Also, taking a sample of MNEs headquartered in one country allowed us to include firms operating in a wide range of manufacturing industries, which contributed to estimating the average effects for the manufacturing sector industries. Finally, limited resources and time for data collection did not permit for a replication of the UK sample to other countries.

5. THESIS STRUCTURE

As outlined in previous sections, there are three distinct research questions this study aims to address with the intended outcome of providing an analysis of the value of knowledge creation strategies with different locational and organisational origin for MNEs. First question evaluates the benefits given by different strategies of international knowledge creation. The second question analyses the value of different combinations of various knowledge creation strategies in the MNE to examine whether it is beneficial to use multiple international knowledge creation strategies simultaneously or the firms should prioritise and opt for a specific strategy instead. The third question analyses whether the environment influences and shapes the relationships examined by the first two research questions.

In order to answer these questions, the thesis adopts the following structure:

Chapter II The second chapter discusses the literature explaining the relationship between knowledge creation and performance in order to identify the major theories in the field which are used to develop the hypotheses.

Chapter III The third chapter presents the various strategies of knowledge creation and the specific locational and organisational origins approach used in this study. The aim is to introduce to the reader in detail the strategies which the firm may choose in order to create knowledge.

Chapter IV The fourth chapter attempts to answer the first research question and examines the performance effect of international knowledge creation strategies of different origin. A U-shaped relationship between both internal and external international knowledge creation strategies and firm productivity is hypothesised and confirmed.

Chapter V The fifth chapter addresses the second research question and analyses whether combining single country and international knowledge creation

in a balanced way is superior for performance compared to an unbalanced approach when the firm prioritises a particular knowledge creation strategy. Also, the chapter examines how MNEs combine internal and external international knowledge creation strategies and the related performance effect with the aim of showing that firms which combine different international knowledge creation strategies differently may exhibit different productivity outcomes. The results show that it is more beneficial for firms to combine knowledge creation strategies in a balanced way.

Chapter VI The sixth chapter addresses the third research question. The aim is to examine whether the relationships studied in the previous two chapters are affected by the environment in which MNEs operate. Environmental instability is hypothesised to affect the relationships and the results substantiate the premise.

Chapter VII The seventh chapter discusses the main findings of this thesis, theoretical and practical contributions and limitations.

CHAPTER II

THEORIES EXPLAINING KNOWLEDGE CREATION AND MNE PERFORMANCE

The phenomenon of interest in this study is the relationship between MNE knowledge creation strategies, specifically international knowledge creation strategies, and MNE performance. To explain this relationship, the study relies on frameworks of Kogut and Zander (1992, 1993) and Birkinshaw and Hood (1998) discussed below.

1. KNOWLEDGE OF THE FIRM AND THE EVOLUTIONARY THEORY OF THE MNE

The evolutionary theory of the multinational enterprise presented in the seminal work of Kogut and Zander (1992, 1993) looked at knowledge as a determinant of MNE competitive advantage. According to the authors, knowledge of the firm is one of the most important factors that drive MNE performance. The framework suggests that firms are reservoirs of knowledge made up of ways in which information is organised and coordinated (Kogut and Zander, 1993). Moreover, MNEs specialise in the sourcing, creation and transfer of knowledge across borders (Kogut and Zander, 1993). Knowledge creation precedes knowledge transfer and refers to the firm's combinative capability of synthesising and applying internal and externally acquired knowledge (Kogut and Zander, 1992). This suggests that knowledge creation can be created using internal strategies and external strategies (Kogut and Zander, 1992).

The framework suggests that the choice of a knowledge creation strategy is determined by the current stock of knowledge, the attributes of knowledge, the firm's advantage in cooperating with partners and the extent to which, if selected, knowledge will provide opportunities for future knowledge creation (Kogut and Zander, 1993). In other words, the authors compare the costs of different knowledge creation strategies as well as the expectation of future revenues (Kogut and Zander, 1993). What is important is viewing the capability of the firm to engage in specific knowledge creation strategies as an option and platform to access future knowledge and drive performance (Kogut and Zander, 1993). Based on these factors, firms will choose to create knowledge using either single country or international strategies and will choose whether to create the knowledge internally within the firm or externally with co-operators outside the firm. To further elaborate on this, we consider the specific cases.

The choice of creating knowledge internally using single country or international strategies (cases in which knowledge is created between two or more units across countries) will be

made when the knowledge that is to be created requires processes and information that are already present in the firm (Kogut and Zander, 1992). If the MNE is currently good at creating this specific knowledge, it will create it using internal strategies (Kogut and Zander, 1992). Furthermore, internal knowledge creation strategies will be used when that knowledge is complex and difficult to teach and when it will be useful as a foundation for the creation of new technologies and capabilities (Kogut and Zander, 1993). The more standardised systems of knowledge creation are in the firm, the chances that the firm will choose internal knowledge creation strategies is higher (Kogut and Zander, 1993).

The firm will choose external single country or international knowledge creation strategies when the external co-creators have superior knowledge that the MNE does not possess (Kogut and Zander, 1992). Also, this strategy of knowledge creation will be chosen when the expectation of revenues that would be lost by failing to accumulate knowledge through this knowledge creation strategy are higher than the expected costs of engaging in this knowledge creation strategy (Kogut and Zander, 1993). Apart from comparing the firm's capability to create knowledge with the capability of potential co-creators, firms will primarily consider the opportunity costs of accessing external knowledge. Therefore, what matters is the type and importance of knowledge that the firm aims to access by engaging in external knowledge creation strategies. The framework suggests that firms will choose these strategies when the potential revenue and future combinative opportunities exceed the costs.

Particular knowledge creation strategies have specific performance effects (Kogut and Zander, 1992). The performance effects will mainly be determined by the degree of transfer and imitability of the knowledge created (Kogut and Zander, 1992).

For instance, engaging in internal strategies, either single country or international, results with a set of knowledge creation capabilities that can be easily transferred through the MNE network and in this way help build the ownership advantage of the whole MNE and positively affect performance (Kogut and Zander, 1993). By applying international internal knowledge creation strategies in particular, MNEs will have access to new knowledge specific to the foreign countries in which units operate and this new knowledge will alter the global knowledge of the whole MNE and result with higher performance (Kogut and Zander, 1993). Because of this advantage, MNEs are driven to build a network of subsidiaries which engage in international, cross-border knowledge creation (Kogut and Zander, 1993). The knowledge created using this strategy will be novel, difficult to imitate and will represent the knowledge based advantage MNEs need to create future knowledge (Kogut and Zander, 1993). In this way, the firm's capability to combine knowledge from different units in order to create new knowledge will determine its current and future performance (Kogut and Zander, 1993).

According to the framework, this process is crucial. It shows the firm's combinative capabilities of creating new knowledge through the new applications of already existing knowledge that the firm has access to through its subsidiary network (Kogut and Zander, 1992).

As in case of internal knowledge creation strategies, firms will benefit from external strategies, either single country or international, based on the ability to combine the knowledge accessed through external partners with the existing knowledge (Kogut and Zander, 1993). In this view, performance growth of the whole MNE depends on whether the units are able to replicate the new knowledge with greater efficiency than its competitors (Kogut and Zander, 1993). Also, the firm will benefit based on the inflow of new external knowledge which will build the knowledge assets of the MNE (Kogut and Zander, 1993). In fact, small increases in the speed and efficiency with which MNE units can create knowledge using internal or external co-operative strategies can be a foundation for significant variations in performance (Kogut and Zander, 1992).

Knowledge theory of the firm also suggests that there are limits to the performance effects of knowledge creation strategies. The more the firm engages in internal and external knowledge creation strategies, both single country and international, the more it will encourage codification of knowledge, which would speed up the knowledge transfer process and these knowledge creation strategies in the future (Kogut and Zander, 1992). However, this will also make the knowledge more accessible to external actors and bring the risk of imitation (Kogut and Zander, 1992). This is the paradox of knowledge creation (Kogut and Zander, 1992). Because knowledge that is created using, for instance, internal knowledge creation strategies will initially be only accessible to the units engaged in the knowledge creation process, the firm will try to codify and simplify this knowledge to make it available across the MNE network, but it will also be more available for imitation and therefore the performance effect might be lost (Kogut and Zander, 1992).

The choice of knowledge creation strategies discussed above is made more complex by the existence of multiple subsidiaries in the MNE which operate in different countries. Apart from the knowledge creation strategy choice, MNEs also need to choose which subsidiaries will engage both in internal and external single country and international knowledge creation and how. The subsidiary evolution theory answers these questions.

2. MNE SUBSIDIARY EVOLUTION: SUBSIDIARY KNOWLEDGE CAPABILITIES AND CHARTER CHANGE

The different strategies of knowledge creation are an outcome of the evolution of the role of subsidiaries in the MNE. The role of overseas subsidiaries in recent decades has changed from serving the domestic market to a more strategic role of knowledge creation. The framework of Birkinshaw and Hood (1998) explains which subsidiaries specifically will participate in these knowledge creation strategies and, by explaining the impact of knowledge creation on subsidiary evolution, it also gives insight into the relationship between knowledge creation strategies and MNE performance.

The evolution of subsidiaries into knowledge creation actors within the MNE is the result of the accumulation of knowledge creation capabilities in these subsidiaries over time (Birkinshaw and Hood, 1998). Knowledge creation capabilities refer to the subsidiary's capacity to combine specific resources using organisational processes to an end result which is new knowledge creation (Birkinshaw and Hood, 1998). Each subsidiary within the MNE has distinct capabilities and therefore, not all subsidiaries will engage in knowledge creation (Birkinshaw and Hood, 1998). The particular country of operation and history of the subsidiary define a unique profile of knowledge creation capabilities for a subsidiary (Birkinshaw and Hood, 1998).

Subsidiary knowledge creation capabilities are in general determined by subsidiary, headquarters, and local environment factors (Birkinshaw and Hood, 1998). This means that the subsidiary itself, by its decisions may influence the development of its capabilities. For instance, it may recognise a knowledge creation opportunity in the market and align and develop its capabilities to fulfil it (Birkinshaw and Hood, 1998). Also, the headquarters may influence subsidiary capabilities by assigning knowledge creation projects to it (Birkinshaw and Hood, 1998). Finally, opportunities and limitations in the location in which the subsidiary operates impacts the capability of that subsidiary (Birkinshaw and Hood, 1998). These three mechanisms interact and define the knowledge creation capabilities of the subsidiary and influence whether or not the subsidiary will engage in the process of knowledge creation (Birkinshaw and Hood, 1998).

The subsidiaries that have the responsibility of engaging in knowledge creation are considered to have a knowledge creation charter (Birkinshaw and Hood, 1998) Knowledge creation charter for a subsidiary is not only a reflection of the subsidiary's knowledge creation capabilities, but it is also an outcome of internal and external competitive forces (Birkinshaw and Hood, 1998). Firstly, there is internal competition for knowledge creation charters. One

subsidiary may take over an existing knowledge creation charter or different subsidiaries may compete for new knowledge creation charters (Birkinshaw and Hood, 1998). Although each subsidiary has unique knowledge creation capabilities, these capabilities may be similar to other subsidiaries' capabilities, which is a foundation for charter shift from one subsidiary to another (Birkinshaw and Hood, 1998). This is the mechanism through which internal forces affect knowledge creation charters in the MNE.

Secondly, external changes may also influence knowledge creation charters of a subsidiary. Elements of the local country environment such as customers, competitors and suppliers may have a favourable effect on a subsidiary's knowledge creation charter (Birkinshaw and Hood, 1998). By operating in a specific country, the subsidiary has superior access to the know-how in that location compared to other subsidiaries, which may result in a knowledge creation charter being given to that subsidiary. Therefore, the framework suggests that subsidiaries which have a knowledge creation charter are the ones which have the necessary knowledge capabilities or for which knowledge creation charter is an outcome of favourable internal and external competitive conditions. In this way, the framework helps in understanding which subsidiaries within the MNE will engage in knowledge creation.

However, the framework also gives insight into the mechanisms behind the relationship between knowledge creation and MNE performance. If the MNE assigns a knowledge creation charter to a subsidiary, it will enhance its capabilities, which is a base for higher performance. Because the subsidiary has highly developed capabilities, it will be more successful in creating knowledge in the future. If a subsidiary outcompetes other subsidiaries for a specific knowledge creation charter, that subsidiary will again have the opportunity to develop better capabilities and higher performance compared to other subsidiaries that did not qualify for the charter. A subsidiary may decide to actively develop its capabilities while performing a knowledge creation charter, which will strengthen its capabilities and improve its performance compared to other subsidiaries. In this way, subsidiaries can evolve and grow through knowledge creation charters and capability development.

In order for these benefits to materialise on the MNE level, the enhanced capabilities of the focal subsidiary need to be available to other subsidiaries throughout the group (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). This is possible through the process of knowledge and capability transfer (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). The focal subsidiary needs to share its superior knowledge and capabilities with other subsidiaries for instance through internal knowledge creation, which will alter the knowledge base of the MNE and build knowledge creation

capabilities of the whole group (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993).

However, knowledge sharing and transfer on MNE level may be challenging. Because the knowledge creation capabilities of a subsidiary are a result of a historical evolution and past experiences of that specific unit, these capabilities cannot be easily transferred (Birkinshaw and Hood, 1998). Even though capabilities are dynamic and they gradually change over time, the framework argues they are still path dependent, which may limit their transfer potential (Birkinshaw and Hood, 1998). In this view, particular subsidiaries may still be in a better position compared to other subsidiaries despite the sharing and transfer of knowledge creation capabilities and ultimately the MNE level effects may be limited.

3. OTHER INTERRELATED THEORIES EXPLAINING THE RELATIONSHIP BETWEEN KNOWLEDGE CREATION AND MNE PERFORMANCE

Apart from the two main frameworks presented above that this study primarily relies on, there are other interrelated theories widely used in IB studies which provide useful insights into the relationship between different knowledge creation strategies and MNE performance and complement the two frameworks. Their specific contributions are discussed below.

3.1. Resource- based view of knowledge and firm performance

Differences in firm performance have been extensively explained in prior literature using the resource-based view (RBV). RBV conceptualises firms as fundamentally heterogeneous in terms of their resources and internal capabilities (Barney, 1991; Peteraf, 1993). According to RBV, only firms which have superior systems and structures are profitable, because they have lower costs or offer higher quality or product performance (Teece et al., 1997). In other words, superior performance can only be achieved based on specific resource advantages which are unique to the firm, inelastic in supply, cannot easily be developed, bought, imitated or substituted (Barney, 1991; Barney, 2001). These resource advantages can be in form of assets, organizational processes, knowledge, capabilities which are owned or controlled by the focal firm and act as potential sources of competitive advantage (Barney, 1991). Therefore, firms which have these types of valuable resources are able to generate above normal profits (Barney, 2001).

Knowledge represents one of such critical resources considering it is generally rare and highly valued, especially in case of proprietary knowledge (Fang et al., 2007), and as such holds potential for competitive advantage building. Proprietary knowledge refers to unique, valuable and often rare personal knowledge from a number of different individuals, tacit in nature and

difficult to replicate and transfer, which the firm terms as idiosyncratic and valuable for its competitiveness (Liebeskind, 1996). These features make proprietary knowledge a potential superior resource. Therefore, when applied to the relationship between knowledge and performance, RBV predicts that knowledge which is valuable, such as knowledge resulting from particular knowledge creation strategies, will bring superior performance growth to the firm, and the firm's ability to identify this type of knowledge is a primary source of gaining and sustaining competitive advantage (Barney, 1991; Grant, 1991).

Although it holds potential for superior performance, not all knowledge held by a firm represents a valuable resource. According to the RBV, only knowledge based assets which hold the conditions of inimitability, non-substitutability, value and rarity have the power to bring above average rents (Barney, 1991; Mesquita et al., 2008). Studies showed that knowledge which conforms to these conditions is knowledge which is either sticky, referring to cases when transfer of such assets is difficult due to its tacit nature, or these resources have been accumulated slowly over time, or the acquisition of this knowledge is subject to path dependence (Jensen and Szulanski, 2004; Mesquita et al., 2008). Examples of such knowledge would include, for instance, knowledge of reengineering of logistics or hardware design processes (Jensen and Szulanski, 2004). Therefore, superior performance, according to RBV, can be achieved only if the firm is able to build distinctive knowledge assets based on their choices of knowledge creation strategies. Also, such valuable knowledge based assets need to preserve and sustain heterogeneity over a longer period of time to enable superior performance, otherwise the benefits would be only short lived (Peteraf, 1993).

In conclusion, the value of RBV applied to knowledge creation and performance is in the ability to explain exactly which strategies of knowledge creation may be beneficial for performance and may account for performance differentials between firms. In this way RBV complements the Kogut and Zander framework. Using insights from RBV we aim to show that different international knowledge creation strategies result with knowledge that changes the firm's knowledge base and capabilities and in this way represent valuable and distinctive knowledge assets which drive performance.

3.2. Expanding the RBV: Combinative capabilities theory and Competitive advantage of interconnected firms

Although the traditional RBV theory helps in defining the value of knowledge creation strategies for performance, it is limited in addressing specifically all sources of where these resources come from and it does not address the issue of how this valuable asset is managed within the multinational firm and how its utilisation, application and deployment within the

firm may affect performance. However, it is important to consider these processes in order to further specify the different strategies of knowledge creation and the related performance effect. Two extensions of traditional RBV theory complement the two main frameworks: combinative capabilities theory, which adds to the Birkinshaw and Hood framework by explaining the knowledge based capabilities that may account for performance variations among firms in more detail, and competitive advantage of interconnected firms, which adds to the Kogut and Zander (1992, 1993) framework in particular by explaining how the firm can access outside knowledge, either from other units within the MNE network or from external partners and gives insights into the value of these knowledge creation strategies.

3.2.1. Combinative capabilities theory

More recent studies argue that building superior resources as proposed by RBV is not enough for achieving superior performance in knowledge driven industries (Teece et al., 1997). For instance, creating new knowledge and protecting it in forms of patents, which act as valuable knowledge based assets, is simply not enough, firms also need to constantly coordinate and redeploy their knowledge assets, as well as be flexible and adaptive in how they create and manage knowledge (Teece et al., 1997). A strategy of simply accumulating valuable knowledge assets is not sufficient to bring performance benefits. In this way, the traditional RBV employs a more static perspective on knowledge resources and does not consider how they can be redeployed further within the firm (Lavie, 2006). Therefore, RBV theory has been extended by the combinative capabilities view of firm advantage, which stipulates that competitive advantage of firms is based on managerial and organisational processes, such as routines, practices and patterns of learning, which in turn are shaped by the firm's specific assets, positions and path dependencies (Teece et al., 1997).

The main question posed by combinative capabilities theory is how the distinctive and difficult-to-replicate knowledge assets and advantages can be built, maintained, and enhanced (Teece et al., 1997), rather than simply how they are accumulated by the firm as developed by the traditional RBV theory. These questions lead to the three concepts which are most important for a firm's knowledge: coordination/integration, learning and reconfiguration (Teece et al., 1997). The authors argue that how the firm internally coordinates its knowledge is very important (for instance how it organises the knowledge creation), as well as how it integrates external knowledge (for instance in alliances and collaborations for knowledge creation). Furthermore, they see learning as an important component, referring to how repetition and experimentation (deployment of skills and knowledge in the organisation) enable tasks to be performed better and quicker, and how new knowledge creation opportunities are identified by the firm (through coordinated search procedures and routines).

The theory defines the last component, reconfiguration, as the firm's ability to recognise the need for and perform internal and external transformation of available knowledge.

As mentioned, combinative capabilities theory argues these three concepts discussed above are shaped by a firm's positions and paths. A firm's positions are determined by its specific assets, such as knowledge, reputation, financial assets, proprietary technology and other (Teece et al., 1997). Finally, the theory emphasises the importance of path dependence and sees knowledge based advantages as a function of a firm's past choices of knowledge creation strategies, its current choices and knowledge creation choices it will opt for in the future (Teece et al., 1997).

When applied to the relationship between knowledge creation and performance specifically, combinative capabilities theory argues that efficient knowledge creation is not enough for performance growth, reinventing processes and creating new valuable knowledge consistently are crucial (Teece, 2007). The development and protection of knowledge based assets must be accompanied by complementary organizational and managerial advances needed to attain and preserve these performance advantages (Teece, 2007). According to the theory, if the firm has valuable knowledge resources which are not supported by complementary combinative capabilities, the positive performance effect can only be sustained for a short period and cannot be sustained in the long term (Teece, 2007). In this context, the necessary combinative capabilities are a set of identifiable and firm specific knowledge related processes as an outcome of knowledge creation strategies which help in sustaining the advantage based on the firm's available knowledge (Eisenhardt and Martin, 2000). Firms need to choose knowledge creation strategies which will give the firm opportunities to build its knowledge base and capabilities and in this way enable future knowledge creation.

Apart from knowledge assets which are internal to the firm, combinative capabilities theory applied to knowledge also emphasises the importance of the external environment. The ability to integrate and combine knowledge within the firm as well as from outside is crucial (Teece, 2007). Specifically, knowledge creation strategies with different internal and external co-creators represent combinative capabilities of the firm (Eisenhardt and Martin, 2000). For instance, a MNE unit may choose to create knowledge with various other units in order to develop capabilities that would enable generating new valuable knowledge and build performance advantages. Also, it may create knowledge in collaboration with external organisations such as universities and research institutions in order to access valuable knowledge and combine it with the internal know-how, and by this process build capabilities that would enable the firm to recognise valuable external knowledge and apply it to develop new products, and in this way achieve superior performance.

In order to further specify the potential performance benefits from external knowledge creation strategies specifically, it is important to consider another extension of the RBV, competitive advantage of interconnected firms. It defines the potential performance benefits stemming from external single country and international knowledge creation strategies.

3.2.2. Competitive advantage of interconnected firms

As mentioned in the paragraphs above, traditional RBV theory views only resources of certain characteristics which are controlled and owned by the firm as determinants of a firm's performance. However, the observation that knowledge can be created in different countries and with different collaborators (discussed in detail in the third and fourth chapter), implies that knowledge as an outcome is not confined solely to the firm itself and can be an outcome of a combination of knowledge between partners, in some cases partners which are outside the firm's boundaries.

Since traditional RBV predicts rents only from knowledge owned and controlled by the firm, it does not account for potential rents based on knowledge accessed from partners and knowledge which is created between partners for which the firm cannot claim full ownership. However, the fundamental characteristic of the MNE is that it is a network of units operating in multiple countries which have the potential to source, create and transfer knowledge across different countries involving different partners (Birkinshaw and Hood, 1998; Ghoshal and Bartlett, 1990; Gupta and Govindarajan, 2000; Kogut and Zander, 1992; Kogut and Zander, 1993). Hence the knowledge creation strategies MNEs choose may also involve different internal and external partners, which may be important for performance (Arora et al., 2014; Berry, 2014).

Competitive advantage of interconnected firms theory offers useful insights in this field. It explains how performance differentials between firms can also be based on resources which are not in a focal firm's full ownership, but which the firm has access to, for instance by engaging in alliances and collaborations (Lavie, 2006). It extends the definition of knowledge as a resource and argues that both knowledge created within the firm and in interconnected environments can account for performance differentials between firms and constitute a base for competitive advantage (Lavie, 2006). Cooperating in alliances or other forms of collaborations drives performance as firms have access to resource endowments of their partners, which are then mobile between them (Lavie, 2006).

Initially, to establish the collaboration, partner firms each commit a part of their knowledge base expecting higher benefits resulting from sharing the knowledge than would be the case

if the firm created and kept the knowledge within its borders (Lavie, 2006). In this way, the firm benefits both from internal, non-shared knowledge and the shared knowledge based on the cooperation in knowledge creation (Lavie, 2006). In co-operative knowledge creation strategies firms have access to knowledge and information of a partner firm (to which the focal firm could not have access otherwise) and this may influence positively the knowledge base of the focal firm and drive performance. Collaborations in knowledge creation generate conditions in which benefits associated with knowledge can be transferred between partner firms. In fact, this theory suggests direct ownership of knowledge resources is not the prerequisite for competitive advantage, actually performance is defined by shared knowledge resources of interconnected firms accessed by engaging in co-operative knowledge creation strategies, either internal or external (Lavie, 2006).

Specifically, the theory predicts four sources of rents which determine firm's performance: (1) internal rent referring to benefits from internal knowledge resources of the firm, (2) appropriated relational rent, which is the rent based on knowledge resources created in co-operations, (3) inbound spillover rent referring to knowledge leakage that the firm appropriates from the non-shared resources of its partners and (4) outbound spillover rent as unintended knowledge leakage that benefits the partner (Lavie, 2006). Therefore, in order to make conclusions about the performance value of knowledge as a resource in a firm, all rents from collaborations and partnerships used to create knowledge must be considered. This insight aids in the understanding of the potential value of different strategies of knowledge creation (discussed in detail in the third chapter).

3.3. Portfolio theory of knowledge and firm performance

The frameworks of Kogut and Zander (1992, 1993) and Birkinshaw and Hood (1998) as well as RBV and its extensions discuss the role of knowledge creation and knowledge creation capabilities, both single country and international internal and external, as important for performance growth. In general, the studies suggest different knowledge creation strategies represent the primary source of performance differences between firms and if MNEs engage in particular strategies, they will experience better performance.

However, firms can also be conceptualised as portfolios of different knowledge creation strategies (Wernerfelt, 1984). What may be important for performance is also how MNEs combine different knowledge creation strategies. Actually, the focus of the second research question in this thesis is whether differences in performance can be explained by variations in the ways in which MNEs combine different knowledge creation strategies.

Portfolio theory argues that firms engage in knowledge creation using different strategies simultaneously in order to keep more options, which are useful in conditions of uncertainty (McGrath, 1997; Nelson, 1961; Vassolo et al., 2004). Particular knowledge creation strategies within the overall knowledge creation portfolio have their specific individual values, but also interact and are interdependent (Vassolo et al., 2004). Portfolio based studies argue that knowledge creation strategies cannot be analysed in isolation and a failure to recognise their co-existence in the overall knowledge creation portfolio may lead to misleading and incomplete conclusions about their performance effects (Vassolo et al., 2004). In this view, the value of different knowledge creation strategies ultimately depends upon the co-existence and combinations of these different knowledge creation strategies in the MNE knowledge creation portfolio.

Studies argue that strategies may be sub or super-additive depending on the extent to which their features belong to a similar or different technological domain, in other words whether they are equivalent to each other in some way (Vassolo et al., 2004). In case of sub-additive portfolios, the value of a portfolio of knowledge creation strategies consisting of, for instance, different types of international knowledge is less than the value of these types analysed independently because they are competing to some extent (Vassolo et al., 2004). The knowledge they provide to the MNE may be similar and therefore the performance effect is limited. In contrast, super-additive portfolios are characterised by a higher portfolio value of international knowledge creation strategies than the value of these strategies analysed separately because they are more valuable when matched (Vassolo et al., 2004). In this way, portfolio theory enabled research into similarities between different knowledge creation strategies.

The seminal study of March (1991) initiated the debate in the literature regarding the validity of employing different knowledge creation strategies in the firm. Since all knowledge strategies compete for resources which are limited, firms make choices between them based on decisions about alternative investments and competitive strategies (March, 1991). The study finds that firms should ultimately combine different knowledge creation strategies in order to survive rather than focusing on just one. Studies extending this view empirically analysed the most appropriate ways to achieve this such as combining different knowledge equally and simultaneously, in a balanced way or constantly shifting between different knowledge strategies (Boumgarden et al., 2012; Geerts et al., 2010; Nicholls‐Nixon and Woo, 2003; Patel et al., 2014; Van de Vrande, 2013). However, there are also studies that argue against combining different knowledge creation strategies due to complexities and higher costs (Hoang and Rothaermel, 2010).

4. CONCLUSION

The theories explained in previous sections offer useful insights into the possible relationship between different knowledge creation strategies and MNE performance, but they also give rise to certain questions, which represent opportunities for specific contributions.

For instance, knowledge of the firm and competitive advantage of interconnected firms indicate that both internal and external knowledge creation is important for firm performance (Kogut and Zander, 1992; Kogut and Zander, 1993; Lavie, 2006). However, the theories do not explain whether there are performance differences between single country and international internal and external knowledge creation. Similarly, the theories recognise that knowledge can be created individually as well as in interconnected environments, but do not differentiate between their MNE performance impacts and whether, when the locational attributes of knowledge creation are also taken into account, these impacts change. Questions such as: does the value of knowledge created between two or more units differ if the units operate in different countries, and is the value of knowledge created between one or more units and external partners different depending on whether the partners come from the same country or if they operate in different countries, arise. Although the theories argue that these knowledge creation strategies all have their merits and can help in building performance advantages, they do not consider the performance effects of each of these strategies specifically. What we do not know is whether and in which way their values differ.

Furthermore, the Birkinshaw and Hood (1998) framework supplemented by combinative capabilities theory explains which subsidiaries will engage in knowledge creation and gives insight into how subsidiaries develop their capabilities through knowledge creation, but it is limited as it primarily considers effects on subsidiary level. It does not specifically address the performance implications of different knowledge creation strategies on MNE level. Although knowledge based resources and capabilities are identified by the RBV and combinative capabilities theory as central for performance growth, studies argue that the understanding of why and how knowledge is so critical is still not fully researched (Teece, 2007). Even though the frameworks suggest that transfer of knowledge creation capabilities from subsidiary to the group level is the primary mechanism through which different knowledge creation strategies may impact MNE performance, they also argue that efficient transfer may be difficult to achieve due to the differences between subsidiaries in the MNE. Therefore, the frameworks do not scrutinise between specific MNE level performance effects of particular knowledge creation strategies and our understanding of the group value of international internal and external knowledge creation strategies in particular remains inconclusive.

The central argument of portfolio theory suggests that the ways in which firms combine knowledge creation strategies may also have an effect on performance. Therefore, studies need to go beyond examining the benefits of different levels of specific knowledge creation strategies and should analyse how firms combine them. We need to question whether MNEs can build their performance by combining international internal and external knowledge creation strategies in different ways, which current research on this topic has not been fully considered. What we do not know is whether a more balanced focus on both internal and external international knowledge creation strategies in the overall knowledge creation strategy of the MNE can bring higher performance or if the MNEs should focus on just one of these strategies because they may bring similar advantages to the firm and therefore their combined value may be limited. Moreover, portfolio theory suggests that knowledge strategies can be less valuable if they replicate the information given by other innovations and therefore questions the notion of co-existence of different international knowledge creation strategies in the overall strategy. This thesis aims to address the questions mentioned and therefore give more insight into the international knowledge creation and MNE performance relationship.

CHAPTER III

ORIGINS OF KNOWLEDGE CREATION IN THE MNE

This thesis, in its pursuit to explain and advance knowledge regarding the phenomenon of international knowledge creation and its effect on MNE performance, relies on a positivist view, empiricism and quantitative methodology approach of philosophy of social science research (Benton and Craib, 2010; Popper, 1959). New knowledge offered is generated through a deductive process based on empirical observations regarding the phenomenon of interest and generalised by applying quantitative, statistical methods (Benton and Craib, 2010). Specifically, we draw from sense experience that confirms or disproves theoretical statements which account for scientific proof and law (Benton and Craib, 2010). The starting point are hypotheses which measure the observable and causality as the overall outcome of the research process (Benton and Craib, 2010).

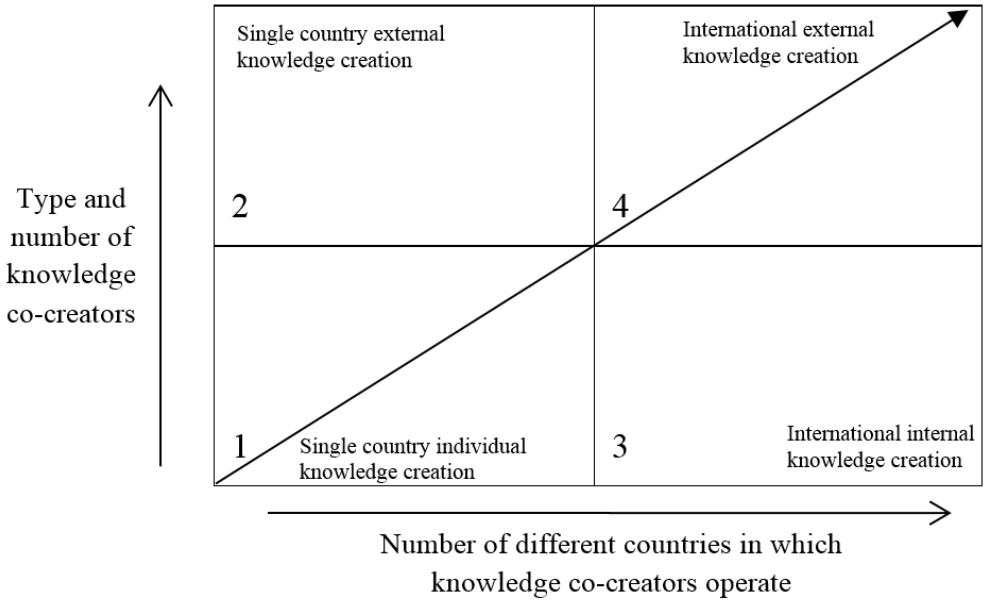
Prior to introducing the hypotheses, methodology and the results, this chapter introduces the different strategies of knowledge creation that the firm can opt for, the overall patterns observed in the data and knowledge creation choices of two MNEs with the aim of providing more context to the phenomenon of interest.

1. LOCATIONAL AND ORGANISATIONAL ORIGINS OF KNOWLEDGE CREATION IN THE MNE

Building on the framework of Kogut and Zander (1992, 1993), MNEs may create knowledge using different strategies presented in Figure 3.1. below.

MNEs, when creating knowledge, make choices regarding the location in which knowledge will be created, in other words whether to create knowledge using single country or international (multi-country) strategies. This represents the locational origin of knowledge creation. Furthermore, MNEs make choices whether the knowledge will be created individually within one unit or headquarters or in cooperation with partners. This represents the organisational origin of knowledge creation. If the MNE chooses to create knowledge in cooperation, it also needs to choose between two types. Cooperation can be internal, in cases when knowledge is created among units belonging to the same MNE, or external, when knowledge is created in cooperation between a unit and external partners beyond the MNE.

Figure 3.1. Locational and organisational origins of knowledge creation



Note: Based on Kogut and Zander (1992)

Therefore, MNEs can position themselves differently when creating knowledge in terms of (1) the locational origin of knowledge creation, whether MNEs use single country or international strategies, and (2) organisational origin, i.e. whether knowledge is created within one unit or using internal or external cooperation strategies (Figure 3.1.).

Based on a sample of 46,712 patents representing knowledge creation strategies granted to 150 MNEs (the sample is discussed in more detail in the fourth chapter), we found that MNEs opt for different knowledge creation strategies based on their locational and organisational origin in the following way:

- on average 54 per cent of all patents was created using single country individual (within one unit or headquarters) or internal (within one or more units operating in the same country) knowledge creation strategies (cell 1, Figure 3.1.),
- on average 19 per cent of all patents was created using single country external (within one or more units or headquarters and external partners, all operating in the same country) knowledge creation strategies (cell 2, Figure 3.1.),
- on average 9 per cent of all patents was created using international internal (within two or more units or headquarters operating in at least two different countries) knowledge creation strategies (cell 3, Figure 3.1.), and

- on average 18 per cent of all patents was created using international external (within one or more units or headquarters and at least one external partner, all operating in at least two different countries) knowledge creation strategies (cell 4, Figure 3.1.).

Prior literature has acknowledged these different knowledge creation choices. However, studies did not take into account the locational and organisational origins simultaneously, to the best of our knowledge. We aim to show that analysing knowledge creation based on locational and organisational origins simultaneously will provide a more accurate account of the performance effects of different knowledge creation strategies.

Apart from the locational and organisational origins of knowledge creation, knowledge in MNEs can be characterised also by the technical origins of knowledge creation, referring to whether the firm chooses to create exploratory or exploitative knowledge. Exploitative knowledge is created using existing technologies available within the firm, whereas explorative knowledge is created using new know-how that is not present in the firm (March, 1991). However, this origin of knowledge creation is beyond the scope of this research due to time limitations.

1.1. Locational origins of knowledge creation

According to the locational origins, knowledge can be created using single country or international strategies. This section explains the differences between them and answers the question when and why firms use these strategies of knowledge creation.

1.1.1. Single country (home or host) knowledge creation strategies

MNE knowledge can be created using single country (one-country, domestic) strategies, either in the home (headquarter) or host country, by one or more units (Kogut and Zander, 1992; Kogut and Zander, 1993) (cell 1, Figure 3.1.).

Traditionally, the majority of single country knowledge was created in the home country of the MNE. Recent studies argue it remains dominant, especially in case of core knowledge projects (Belderbos et al., 2013; Di Minin and Bianchi, 2011). According to data used in this study, still a considerable 14 per cent of all patents was created within the home (headquarter) country. The main reasons are centralisation of intellectual property management which lowers the risk of valuable knowledge being acquired by competitors (Di Minin and Bianchi, 2011) and issues such as coordination costs of international R&D and maintaining the embeddedness of firm's R&D in home country innovation systems (Belderbos et al., 2013).

Apart from home country strategies, subsidiary or host country knowledge creation constitutes an important single country knowledge creation strategy (Frost et al., 2002; Lahiri, 2010). Some MNEs create knowledge within their units, particularly units which have a range of internal and external sources available to learn from and the capabilities to absorb and utilise them (Birkinshaw and Hood, 1998; Cohen and Levinthal, 1990; Phene and Almeida, 2008). In fact, based on our data, a substantial 38 per cent of all patents was created in the host country. The units build upon unique localized knowledge, for instance by using research of local institutions, and transfer that knowledge throughout the MNE (Almeida, 1996; Belderbos et al., 2008; Birkinshaw and Hood, 1998; Kogut and Zander, 1993). This specific single country knowledge creation strategy is important because accessing valuable local knowledge is only possible by operating in geographical proximity of the location, which motivates firms to increasingly choose host country knowledge creation strategies (Frost, 2001). Furthermore, these strategies are especially valuable for the rest of the MNE when the units are supplementing the already existing internal knowledge base with new localised know-how (Belderbos et al., 2008).

Generally, firms will choose single country knowledge creation strategies depending on certain characteristics of the country and firm itself such as local knowledge reservoirs, firm knowledge creation efficiency and possibility of spillovers depending on intellectual property rights protection (IPR) regimes (Kogut and Zander, 1992; Kogut and Zander, 1993). A country will be an attractive knowledge creation location if it has a large local market size and significant local scientific and educational infrastructure and the potential for intra- and inter-industry spillovers (Cantwell and Piscitello, 2002). Also, firm characteristics affect the choice of locational origins of knowledge creation. For instance, if the capability of the unit to create knowledge is higher, it is more likely that the particular unit will create more knowledge in its host country (Birkinshaw and Hood, 1998; Frost, 2001). Furthermore, when the MNE does not possess strong headquarter knowledge creation potential, it will choose to create more knowledge in host countries (Belderbos et al., 2008; Kogut and Zander, 1992; Kogut and Zander, 1993). However, a country's IPR regime can be a significant deterrent of host country knowledge creation because of difficulties in maintaining control over the MNEs' most valuable knowledge (Mansfield and Lee, 1996). The negative effect of weak IPR and the risk of unintended outgoing spillovers of MNE knowledge is highest in countries where the domestic companies are direct competitors of the MNE (Belderbos et al., 2008), in which case it is less likely that the firm will create knowledge in that particular host country.

Furthermore, knowledge created in a single country can be an outcome of cooperation between one or more units and external partners operating in the same country (Kogut and Zander, 1992; Kogut and Zander, 1993) (cell 2, Figure 3.1.). Following the data used in this study, a

significant proportion of all patents, 19 per cent, was created in partnership with domestic external partners. Collaboration with various local stakeholders is an established knowledge creation strategy for MNEs. Studies found, for instance, a significant effect of university research on corporate patents (Cassiman et al., 2010; Jaffe, 1989), but also other collaborative networks of suppliers and clients (Nieto and Santamaria, 2007) and specialist knowledge providers (Tether and Tajar, 2008). Therefore, local partners are important, especially in environments where they are a part of an agglomerated, knowledge intensive community (Cantwell and Piscitello, 2002), from which MNEs can gain most benefits.

However, there are disadvantages related to single country knowledge creation strategies. Since they are limited by the available pool of knowledge in a specific country, they do not draw upon diverse knowledge sources, which may limit the novelty and value of the knowledge created. In fact, the main feature of single country knowledge is that it depends more on homogeneous, within group behaviour of individuals with similar backgrounds and builds on and recycles the expertise available within one location, which can lead to redundant ideas and processes (Berry, 2014; Burt, 2004).

Ultimately, the choice of creating knowledge using single country strategies, either home or host, will depend on the trade-off between home and host country characteristics such as potential knowledge reservoirs, competitors, importance of spillovers, the potential and efficiency of intra-firm transfers and whether the unit has the necessary capability to create knowledge (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993).

1.1.2. International (multi-country) knowledge creation strategies

MNEs also create knowledge using international (multi-country) strategies. International knowledge creation refers to the cases in which knowledge is created in form of a collaboration between at least two co-operators from at least two different countries (Berry, 2014), which can be either internal when the knowledge is created between two or more units (cell 3, Figure 3.1.) or external when the partners operate outside the MNE network (cell 4, Figure 3.1.) (Kogut and Zander, 1993).

MNEs, by having units which operate in various countries, possess a unique organisational setting that enables them to engage more easily in these international knowledge creation strategies, derive specific benefits based on recombination and sharing of knowledge across borders and ultimately gain difficult-to-replicate advantages, compared to domestic firms (Ghoshal and Bartlett, 1990; Gupta and Govindarajan, 2000; Kogut and Zander, 1993). Creating knowledge using international strategies matters, especially in case of complex innovations and in industries with rapid technological change (Kogut and Zander, 1993; Patel et al., 2014). Furthermore, by engaging in these knowledge creation strategies MNEs generate

performance advantages by combining knowledge from various country locations (Gupta and Govindarajan, 2000; Kogut and Zander, 1993; Patel et al., 2014). Prior studies showed an increasing trend towards international knowledge creation in the past 20 years, growing from an initial one-fifth to one-third of all new foreign patents (Berry, 2014). The data used in this study confirms this trend as around 27 per cent of all patents originated internationally.

Studies showed that internationally created knowledge has significant benefits for the MNE. Compared to single country knowledge creation, it brings together a wider pool of technological knowledge and the knowledge resulting from these strategies is more likely to be utilised in subsequent innovations (Berry, 2014). Since countries have diverse knowledge reservoirs based on national differences in technical activity (Chung and Yeaple, 2008), internationally created knowledge brings together diverse clusters of know-how, which has more intrinsic value for the MNE (Berry, 2014). Considering that these processes result in knowledge that is more technologically diverse compared to those developed in single country, international knowledge creation also enables further innovations within MNEs (Birkinshaw and Hood, 1998; Kogut and Zander, 1993; Yamin and Otto, 2004).

However, international knowledge creation also involves significant risks and governance costs. Effective management of such strategies can be costly because of the difficulties of knowledge sharing across locations (Kogut and Zander, 1993). The lack of absorptive capacity of partners, causal ambiguity and challenges of managing relationships between partners make international knowledge creation challenging (Szulanski, 1996) and result with a higher cost compared to single country knowledge creation. Furthermore, engaging in various international knowledge creation strategies can require controlling very complicated organizational structures needed for these strategies, which can be costly (Berry, 2014). Accessing a mix of knowledge from different countries can also create inefficiencies and duplication of ideas (Berry, 2014).

The fact that around a third of all knowledge originated internationally indicates that there are MNEs that cannot always use this knowledge creation strategy. This may be due to their capabilities as some firms are not able to draw on and combine knowledge from two or more diverse countries (Birkinshaw and Hood, 1998). For instance, MNEs which create their knowledge mostly in headquarter country do not have the absorptive capacity and mechanisms set up that would scan for and adopt knowledge from a variety of international locations and partners and therefore will engage less in international knowledge creation strategies (Birkinshaw and Hood, 1998; Cohen and Levinthal, 1990).

1.2. Organisational origins of knowledge creation

According to the organisational origins of knowledge creation, knowledge can be created either using single unit (individual, solitary) or cooperative strategies. Cooperation can be internal or external.

Knowledge using single unit, individual strategies is a single country knowledge creation strategy. Using this strategy, knowledge can be created either in the headquarters (home country) or within one unit (host country). Similarly as in the case of single country knowledge creation, firms which opt for this specific strategy aim for more centralised knowledge creation in order to protect and effectively manage the development of core projects and to lower governance costs (Belderbos et al., 2013; Di Minin and Bianchi, 2011; Kogut and Zander, 1993).

Collaborative knowledge creation refers to cases when knowledge is co-created between two or more partners (cell 2, 3, 4, Figure 3.1.). These collaborations can be internal or external. Internal knowledge creation is when the firm chooses to create knowledge in collaboration with one or more units within the same MNE (cell 3, Figure 3.1.). External knowledge creation is when the firm chooses to create knowledge in collaboration with one or more co-creators or partners outside the MNE (cell 2 and 4, Figure 3.1.). Firms which engage extensively in both strategies aim to access diverse knowledge outside the focal unit and benefit more if the knowledge accessed is outside the main technological domain (Belderbos et al., 2010; Kogut and Zander, 1993).

Internal and external knowledge creation can be either single country or international, depending on whether all the partners operate in the same country or more than one country. Internal and external international knowledge creation represent the most complex strategies of knowledge creation. We explore internal and external knowledge creation strategies below.

1.2.1. Internal knowledge creation

Internal knowledge creation refers to strategies in which knowledge is created between two or more units belonging to the same MNE, which can either operate in the same country (single country knowledge creation) (Figure 3.1., cell 1) or in two or more different countries (international knowledge creation) (Figure 3.1., cell 3).

Units may engage in internal knowledge creation strategies for two different strategic aims. Firstly, units can collaborate in order to develop a distinctive product that suits the specific market segment and country location, by bringing together results of their own applied research and technical competence (Pearce, 1999). Secondly, internal knowledge creation may

aim to develop the MNE core knowledge further in which case the collaboration will focus on basic or applied research by supplementing the competences of know-how available in the MNE with the specifics of technological heritage inherent to the host countries in which the units operate (Pearce, 1999).

Internal knowledge creation can be organised in a variety of strategies which may vary by duration and scope. For instance, it can take a form of a major collaborative project between units focused on developing novel innovations in the field which may take several years to complete and involves significant resource commitment (Frost and Zhou, 2005). On the other hand, it can be a temporary project with less resources allocated such as site rotations, exchange programs and peer assistance (Frost and Zhou, 2005).

The units engaging in internal strategies of knowledge creation are the ones which as a prerequisite have the technical and knowledge capabilities to carry out these activities based on their previous knowledge creation undertakings, level of resources available for knowledge creation and, additionally, which are embedded in the social communities of knowledge sharing within the MNE, which facilitates these processes (Birkinshaw and Hood, 1998; Cohen and Levinthal, 1990; Frost and Zhou, 2005; Szulanski, 1996).

Internal knowledge creation can be a single country strategy in cases when knowledge is created between two or more units within the MNE operating in the same country, either headquarter or host country. Empirical evidence used in this study shows a very limited number of patents developed in a single country between two or more units, less than one per cent of all patents. The reason for this might be that MNEs in most cases establish only one unit in a particular country which is responsible for knowledge creation. Also, it might be that the benefits of internal knowledge creation within a single country are limited because of overlapping ideas based on the same local knowledge reservoir, which are not valuable to the firm's portfolio of knowledge (Kogut and Zander, 1993; Vassolo et al., 2004). Due to this risk of redundancy, MNEs rarely engage in single country internal knowledge creation.

Internal knowledge creation can also be international (Figure 3.1., cell 3) when knowledge is created between two or more units within the same MNE, but operating in at least two different countries. As mentioned, the MNE is a network of geographically dispersed (Ghoshal and Bartlett, 1990), knowledge sharing units (Gupta and Govindarajan, 2000), that can create knowledge by re-combining know-how across locations (Argote and Ingram, 2000; Buckley and Carter, 1999; Kogut and Zander, 1993). According to empirical data used in this research, MNE units participate extensively in these collaborations. Around 32 per cent of all internationally created knowledge was internal, between MNE units operating in various countries.

International internal knowledge creation offers various benefits such as access to diverse know-how, it contributes to absorptive capacity and builds social capital in MNE units and increases the probability for future knowledge sharing and development (Birkinshaw and Hood, 1998; Frost and Zhou, 2005; Kogut and Zander, 1993). Since the units possess specific location based knowledge and are specialised in their knowledge creation processes, these advantages are brought together and the firm is able to benefit from this collectively (Kogut and Zander, 1993). Moreover, collaboration enables more efficient knowledge creation by sharing costs between units and leveraging factor cost differentials across countries in which the units operate (Hanson et al., 2005; Kogut and Zander, 1993).

For the benefits of international internal knowledge creation to materialise, MNEs need to effectively coordinate knowledge creation activities across the MNE and extensively share and exchange knowledge and information (Kogut and Zander, 1993). International internal knowledge creation is facilitated by knowledge integration processes between the units such as social interaction (Noorderhaven and Harzing, 2009), R&D co-practice (Frost and Zhou, 2005) or manufacturing integration (Berry, 2014). Intensive social interaction between units is the main factor which stimulates internal knowledge creation by supporting cross unit dialogue, a shared understanding of other units' technical and knowledge creating capabilities (Frost and Zhou, 2005) and creating a social context for collaboration (Noorderhaven and Harzing, 2009). Studies showed that firms which use international collaboration teams which frequently communicate with the aim to gather information about knowledge differences among countries positively influence cross-border knowledge flows and further internal knowledge creation (Kogut and Zander, 1993; Subramaniam and Venkatraman, 2001).

However, the benefits of both single country and international internal knowledge creation may be limited as these strategies require higher resource commitment compared to individual knowledge creation. Internal knowledge creation between partner units may lead to information asymmetry and incentive misalignment and these risks are higher if there are more internal co-creators involved (Harris et al., 1982; Lu and Beamish, 2004). Units may have different motives, information, know-how and knowledge creation models, which can make initial communication and collaboration on a joint project difficult at first. Also, developing a clear strategy of tasks to be undertaken in a cross-unit environment may require significantly more effort. Moreover, the positive effects may apply only to the units involved and not translate across the whole MNE (Alnuaimi et al., 2012).

1.2.2. External knowledge creation

Although the MNE is a network of geographically dispersed units, it is also embedded in an external network of other organisations with which it interacts and which represent potential knowledge creation partners (Ghoshal and Bartlett, 1990; Kogut and Zander, 1993; Lavie, 2006). Therefore, MNE knowledge can also be created through collaboration with external partners (Cassiman and Veugelers, 2006; Chesbrough, 2006; Kogut and Zander, 1993). External knowledge creation refers to knowledge that is created between one or more MNE units and one or more co-creators outside the MNE, all of which can operate either in the same (single country external knowledge creation) (cell 2, Figure 3.1.) or two or more different countries (international external knowledge creation) (cell 4, Figure 3.1.). This type of knowledge transcends the organisational boundary of the MNE.

Several trends in the global economy drive the growth of these knowledge creation strategies. Apart from the traditional motive of accessing and exploiting valuable knowledge based in different countries (Kogut and Zander, 1993), firms engage in these collaborations due to an increasing interdependence between technologies and the growing costs of retaining leadership in a particular technological domain (Narula and Hagedoorn, 1999). Many knowledge intensive industries require interdisciplinary know-how and skills in knowledge creation in order to gain advantages, which adds to the growing costs of knowledge creation and makes it challenging to create knowledge individually, without engaging in any form of collaboration (Narula and Hagedoorn, 1999).

External knowledge can be created by engaging in R&D cooperation, strategic technological partnering, joint ventures, mutual exchange or know-how trading (Arora et al., 2001; Narula and Hagedoorn, 1999; Veugelers, 1997). According to the data in this study, around 37 per cent of all patents were created in collaboration with various external partners, beyond the MNE organisational boundaries, either in a single country (19 per cent) or internationally (18 per cent). In fact, this strategy of knowledge creation is the second most used following the dominant individual knowledge creation strategy.

MNEs engage in these knowledge creation strategies when potential rents from accessing the external knowledge held by external co-creators outweigh the expected costs (Appleyard, 1996; Kogut and Zander, 1993). Traditionally MNEs engaged in external collaborations to overcome local knowledge disadvantages. Studies showed that partnering with local firms belonging to a different country is a primary strategy for accessing valuable location based intangible assets such as know-how about the local economy, competitors, politics, culture, local demands and tastes, local labour force, information regarding distribution channels,

infrastructure, raw materials and other factors necessary for performing operations in specific location (Kogut and Zander, 1993; Makino and Delios, 1996).

Furthermore, firms will choose external knowledge creation strategy depending on their previous knowledge collaborations (Birkinshaw and Hood, 1998). Previous collaborations and contacts between potential co-creators increase the probability that the firm will engage in an external knowledge creation strategy such as a strategic alliance (Birkinshaw and Hood, 1998; Vanhaverbeke et al., 2002). A possible motive is also internal and external knowledge creation complementarity as studies showed that marginal return to one knowledge creation strategy increases as the intensity of the other increases (Cassiman and Veugelers, 2006; Kogut and Zander, 1993). In fact, studies showed that many firms use both strategies of knowledge simultaneously because external knowledge creation may leverage the efficiency of internal knowledge creation (Cassiman and Veugelers, 2006).

Studies from both economic and management disciplines emphasise the importance of international external knowledge creation in particular. In fact, international external knowledge creation is the new frontier for knowledge creation. Firms are increasingly opening their knowledge creation borders to external actors, engaging in import and export of new ideas and by doing this they are lowering the costs, risks and improving the speed and quality of knowledge creation (Rigby and Zook, 2002). Recent research showed that firms create knowledge in more open models of innovation (Chesbrough and Crowther, 2006; West and Bogers, 2013). Specifically, studies argue that competitive advantage is a result of inbound open innovation, the practice of leveraging external knowledge and discoveries of others in the knowledge creation strategy (Chesbrough and Crowther, 2006). Firms increasingly recognise that valuable knowledge is embedded in the external, in many cases international environment, and can be accessed by external international knowledge creation strategies. Firms are discontinuing the strategy of investing in large and costly research and development centres for individual knowledge creation and instead create knowledge by collaborating (Chesbrough and Crowther, 2006).

According to the data in this study, a significant proportion of international knowledge was external, on average for each ongoing internal international knowledge creation patent, the firm engages in 1.5 external international patents, suggesting that external international patents are the dominant form of international knowledge creation. However, it is also worth noting that, taking all strategies of MNE knowledge creation into account, there remains a dominant share of individual knowledge creation.

Firms may also face various challenges in creating external single country and international knowledge. External knowledge primarily needs to fit the internal capabilities and existing

knowledge base of the MNE and internal R&D personnel needs to be fully receptive to the new knowledge (Birkinshaw and Hood, 1998; Kogut and Zander, 1993; Veugelers, 1997). Also, this knowledge creation strategy requires the development of suitable R&D infrastructure and schemes, which support both scanning of new external knowledge and its effective utilisation (Birkinshaw and Hood, 1998; Veugelers, 1997). Internal R&D personnel needs to be equipped to successfully and effectively absorb external know-how (Cohen and Levinthal, 1990) and the overall MNE strategy needs to support and emphasise the link between internal and external knowledge (Veugelers, 1997).

Also, extensive commitment to external knowledge creation can have significant implications for the MNE such as the need for more proactive knowledge management on the MNE and unit level, constant monitoring of external technologies and know-how and may require organisational changes and transitions to structures and models which can support these novel strategies of knowledge creation, all of which may bring higher costs (Arora et al., 2001). Also, external knowledge development and open innovation models, together with the development of markets for technology may lower the barriers to entry and significantly increase competition (Arora et al., 2001).

2. KNOWLEDGE CREATION STRATEGIES OF UK MNEs, 2003-2012

The empirical evidence used in this study and based on 46,712 patents showed that MNEs adopt knowledge creation strategies of different locational and organisational origins, displayed in Figure 3.2.

As mentioned at the beginning of this chapter, a dominant 52.4 per cent share belongs to individual single country knowledge creation, with the majority being created in units (38.2 per cent of total patents), rather than headquarters (Figure 3.2.). Firms also intensely create knowledge using single country external strategies, 19.1 per cent share of total, where again the units dominate (Figure 3.2.). However, firms rarely engage in single country internal strategies, 0.01 per cent of total (Figure 3.2.).

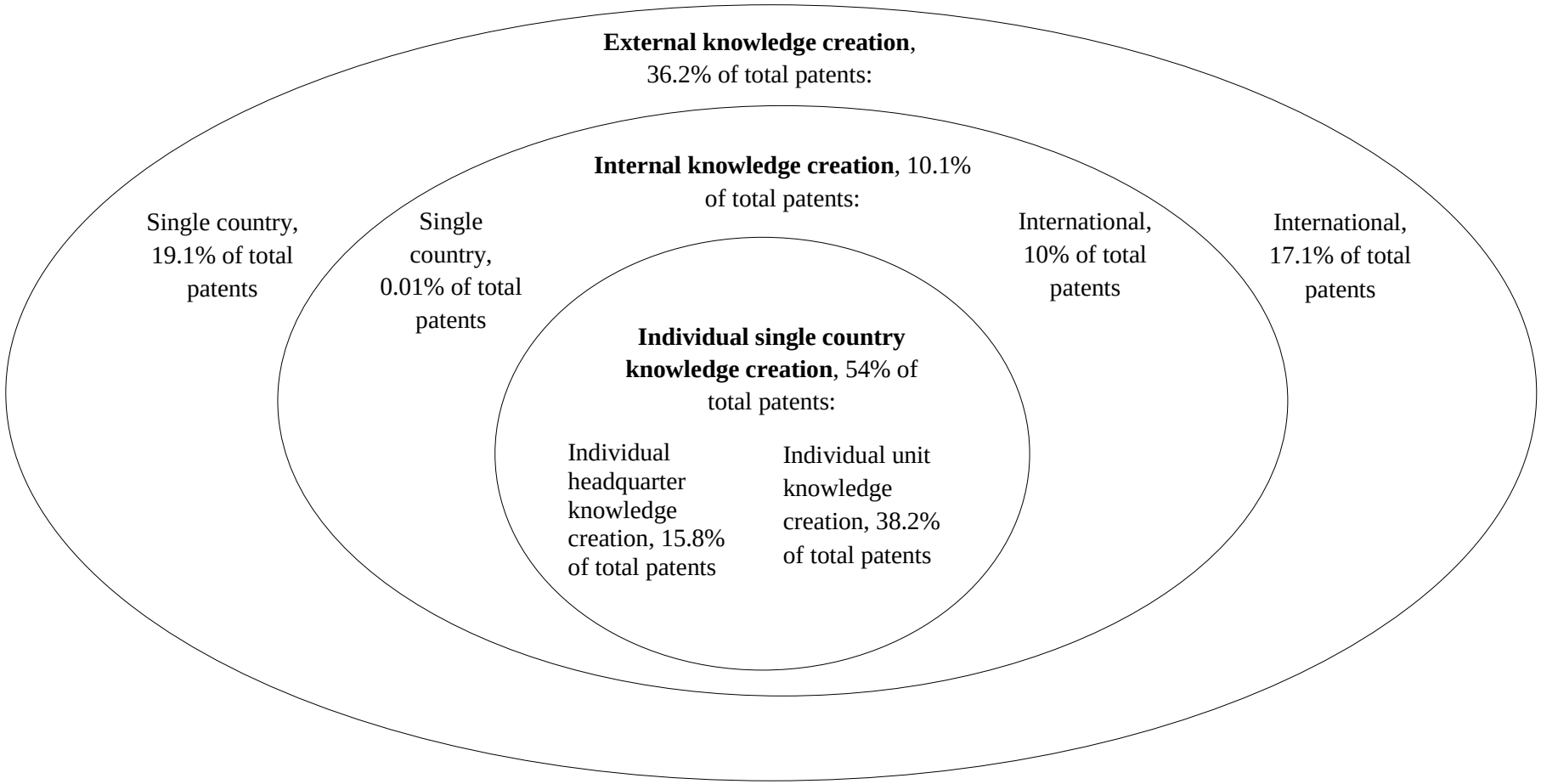
Firms also create knowledge using international strategies, with either other MNEs units (10.1 per cent of total patents) or other external partners outside the MNE (17.1 per cent of total patents (Figure 3.2.). Therefore, on average 27 per cent of all patents of both MNE headquarters and subsidiaries are oriented towards different international knowledge creation strategies. The significant share of these knowledge creation strategies make analysing their exact performance effects interesting, which this research aims to address in the fourth, fifth and sixth chapter.

Figure 3.3. shows the annual growth of knowledge creation strategies of different locational and organisational origins from 2004 to 2012 with 2003 as base year. Total knowledge creation (patents) grew around 16 per cent in 2012 compared to 2003 (Figure 3.3.). Single country knowledge creation grew more on average than total international knowledge creation comparing the two years. However, certain strategies of international knowledge grew significantly in 2012 compared to 2003. For instance, international external knowledge creation grew 43 per cent in 2012 in comparison to base year (Figure 3.3.). Other studies have also recorded a growing trend of multi-country knowledge (Berry, 2014).

In contrast, there was a significant drop in internal international knowledge (Figure 3.3.), showing that MNEs did not find it beneficial enough to pursue as a knowledge creation strategy, which may be for various reasons. Firstly, it may be the case that units transferred fully the knowledge from their specific country locations to the MNE level and it was not useful to pursue further collaboration with other units, as the knowledge is already present in the MNE. Secondly, MNEs may have significantly changed their knowledge creation strategies in the past ten years. In pursuit of the diversity held in different countries, MNEs may have found it more efficient and cost effective to create knowledge in collaboration with external partners and appropriate the diversity in this way rather than by establishing a research unit in a respective location which would then absorb the new localised knowledge and transfer it to MNE level through internal international knowledge creation.

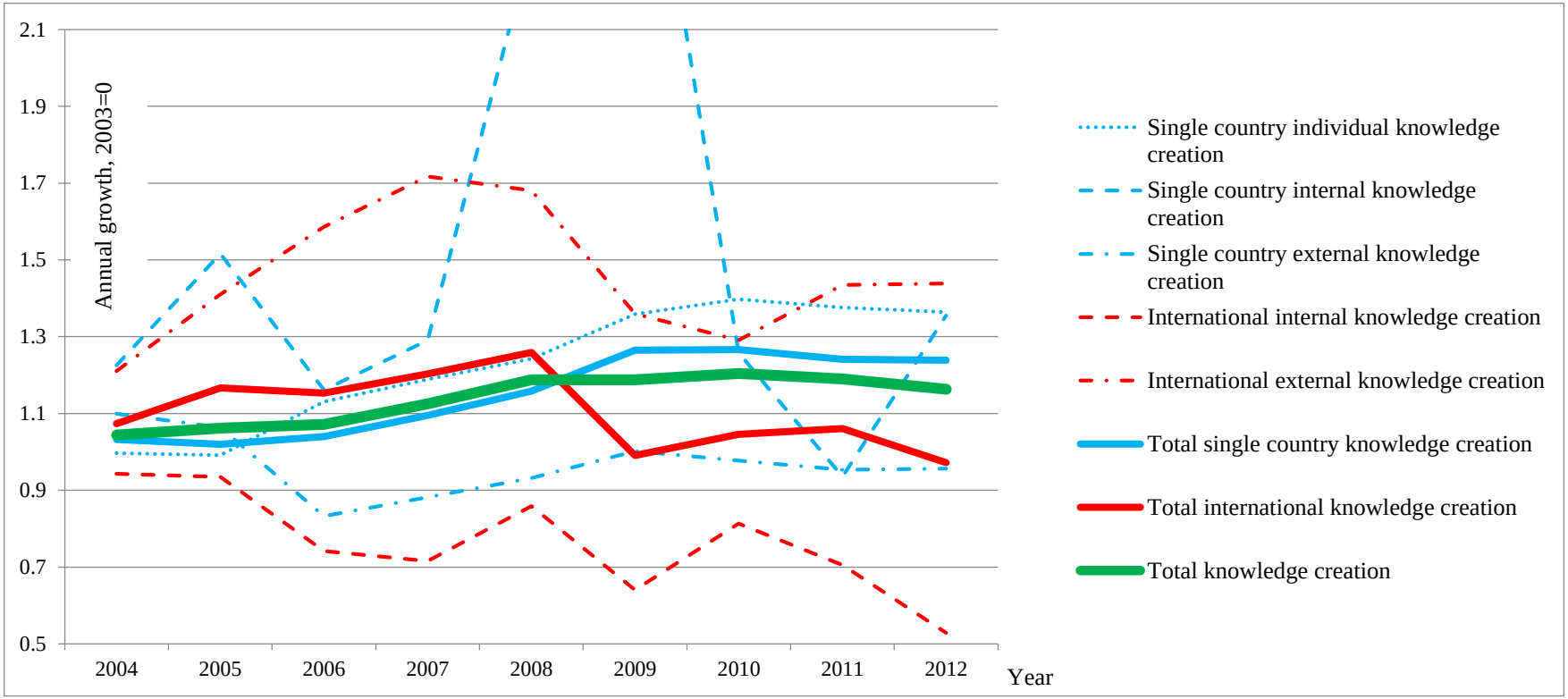
In conclusion, prior studies and these trends show that MNE knowledge creation can be of different origin and therefore may have different performance implications for the MNE.

Figure 3.2. Knowledge creation with different locational and organisational origin in UK headquartered MNEs, 2003-2012



Note: Based on a sample of 46,712 patents granted to 150 UK headquartered MNEs and their first level units in the 2003 to 2012 period. Source: European Patent Office.

Figure 3.3. Knowledge creation with different locational and organisational origin in UK headquartered MNEs, annual growth 2004-2012, 2003=0



Note: Based on a sample of 46,712 patents granted to 150 UK headquartered MNEs and their first level units in the 2003 to 2012 period. Source: European Patent Office.

3. KNOWLEDGE CREATION STRATEGIES OF VODAFONE GROUP PLC AND GLAXOSMITHKLINE PLC

MNE knowledge creation can be of different origin based on the knowledge creation strategy employed by the MNE, which is defined by the firm's locational and organisational knowledge creation choices. In this section we briefly discuss knowledge creation choices and strategies employed by two MNEs with the aim to demonstrate how MNEs differ in their knowledge creation strategies. Therefore, the purpose of introducing their knowledge creation strategies is purely illustrative, to show how a firm's choices can differ, which aids in providing context for the hypotheses introduced and tested in the following three chapters.

The firms were selected from the sample because they show significant differences in their knowledge creation strategies. Both firms are manufacturing MNEs headquartered in the UK which operate in various countries and differ in terms of size, number of units and most importantly, knowledge creation strategies. They are among the top non-financial MNEs ranked by foreign assets (UNCTAD, 2014b). The discussion and figures of their knowledge creation strategies are based on their patenting activity in the ten year period from 2003 to 2012.

3.1. Knowledge creation strategies of Vodafone Group PLC

Vodafone was founded 30 years ago, it employs more than 86,000 people and has a turnover of around USD 74,300 million (2012). Its 472 first level subsidiaries operate in more than 40 countries. Vodafone showed intense knowledge creation activity in the ten year period during which it recorded 2,186 granted patents in total. Despite a significant number of subsidiaries, only 19 units (including headquarters) had patenting activity in the period, as these recorded one or more granted patents.

Vodafone's knowledge creation strategy is illustrated in Figures 3.4. and 3.5. Figure 3.4. shows the annual growth of knowledge created with different origins in the 2004 to 2012 period, with 2003 as the base year. Figure 3.4. aimed to capture the locational and organisational origins of knowledge created within the selected ten year period (2003 to 2012).

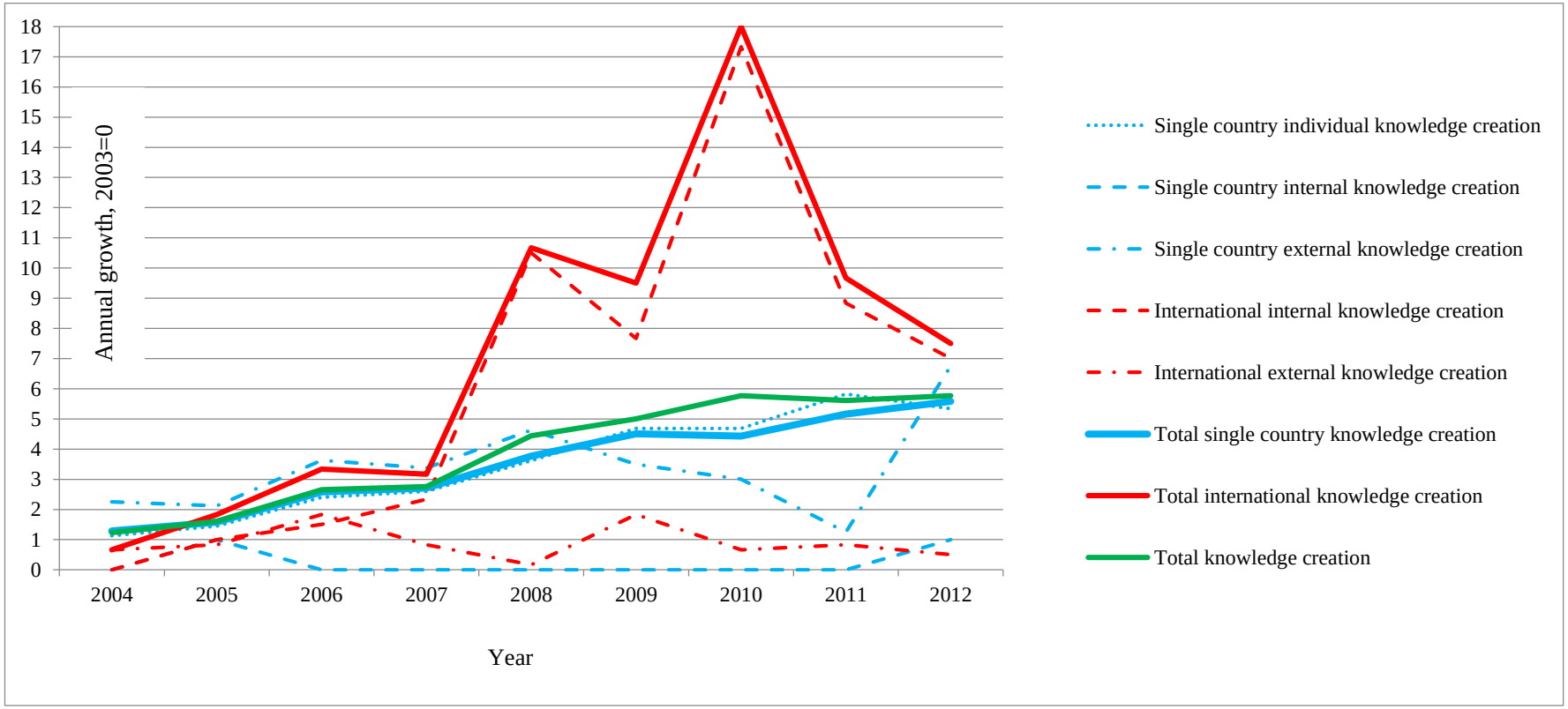
With regards to the locational origins of knowledge creation, the MNE showed a dominance of single country (domestic) knowledge creation strategies which recorded a relatively steady growth (Figure 3.4.). Around 82 per cent of all patents were created using single country strategies, out of which a large majority, 73 per cent was developed in the subsidiaries rather than headquarters (Figure 3.5.). However, the knowledge creating subsidiaries operate in ten different countries, which indicates that the MNE appropriated knowledge from different

country locations. The remaining lower share of 18 percent of total patents was developed internationally, in a multi-country environment with at least one partner from a different country. The share of international patents was growing in the period, the number of which was on average 7.1 times per year higher compared to base year, with the strongest growth period being between 2009 and 2010 (Figure 3.4.). The high rate of growth compared to single country patents shows that the firm deployed more of their knowledge creation resources towards international knowledge creation strategies.

Based on organisational boundaries, we can observe that a vast majority of all knowledge was created individually, 70 per cent, while the remaining share of knowledge creation was developed in form of collaboration. However, the average rate of growth of collaborative patents surpassed the growth rate of individual patents in the period, driven by the high growth of international knowledge creation, which was 10 times higher in 2008 and 2010 than in 2003 (Figure 3.4.). The firm engaged in international knowledge creation more than single country collaborations also in absolute terms, taking around 60 per cent share of all collaborative knowledge creation. The type of partnerships depended on the location, where a distinct pattern emerged. In case of international knowledge creation, 85 per cent of international patents were developed internally, within the MNE with one or more units operating in different countries. However, from Figure 3.5. we can see that only a limited number of units participate in these partnerships. With regards to single country knowledge creation, the type of established partnerships differs as the vast majority of these collaborations are external, with partners outside of the MNE network operating in the same country. Although external single country knowledge creation did not achieve the high growth rates as international internal knowledge creation, still this type of knowledge recorded a steady average growth as their number was 3.2 times higher compared to base year. The number of units participating in these types of collaborations is greater than in case of international knowledge creation (Figure 3.5.).

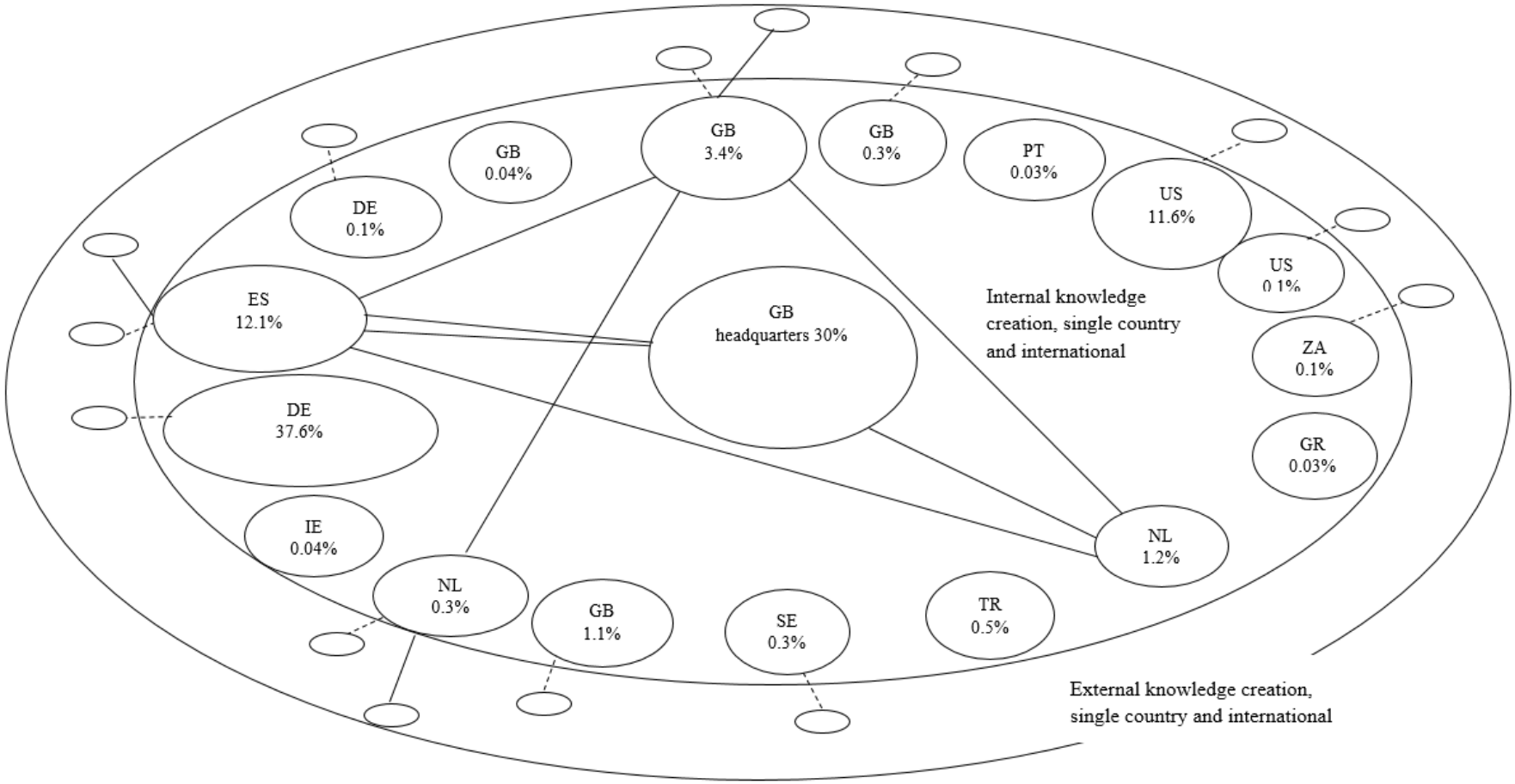
In conclusion, it can be observed that the firm employs a fairly simplified knowledge creation strategy considering that only three units account for around 53 per cent of all developed patents. Also, the majority of units develops either individual or external single country or international knowledge creation, whereas only five units engage in internal knowledge creation, which is in all cases international.

Figure 3.4. Knowledge creation with different origin in Vodafone Group PLC annual growth 2004-2012, 2003=0



Note: Based on a sample of 2,186 patents created by Vodafone Group PLC and its first level units in the 2003 to 2012 period. Source: European Patent Office.

Figure 3.5. Locational and organisational origins of knowledge creation in Vodafone Group PLC, 2003 to 2012



Note: The main two circles represent internal or external knowledge creation, both single country and international, while the small circles represent a particular knowledge creating unit, with a note of the country of operation and percentage share of total patents granted to the unit. The empty circles represent external partners. The full lines represent international knowledge creation, whereas the dotted lines represent single country knowledge creation. Based on a sample of 2,186 patents created by Vodafone Group PLC and its first level units in the 2003 to 2012 period. Source: European Patent Office.

3.2. Knowledge creation strategies of GlaxoSmithKline PLC

GlaxoSmithKline is a UK headquartered multinational as of 14 years. It has more than 98,000 employees and a turnover of around USD 41,700 million (2012). Its 139 first level subsidiaries operate in more than 45 countries, out of which 33 (including the headquarters) were creating knowledge. The firm recorded 16,143 granted patents in total in the ten year period. The knowledge creation strategy of GlaxoSmithKline is illustrated in Figure 3.6. and 3.7.

Compared to Vodafone, we can observe that the knowledge creation strategy of GlaxoSmithKline differs in various aspects. Firstly, the multinational has a larger number of units creating knowledge, 33 in total. Secondly, the majority of knowledge was created in form of collaboration (more than 90 per cent of all granted patents), whereas in Vodafone individual knowledge creation dominated. Also, compared to Vodafone, this firm recorded relatively lower rates of growth of knowledge with different origin throughout the period, which shows that its knowledge creation strategy remained more stable compared to the previous example.

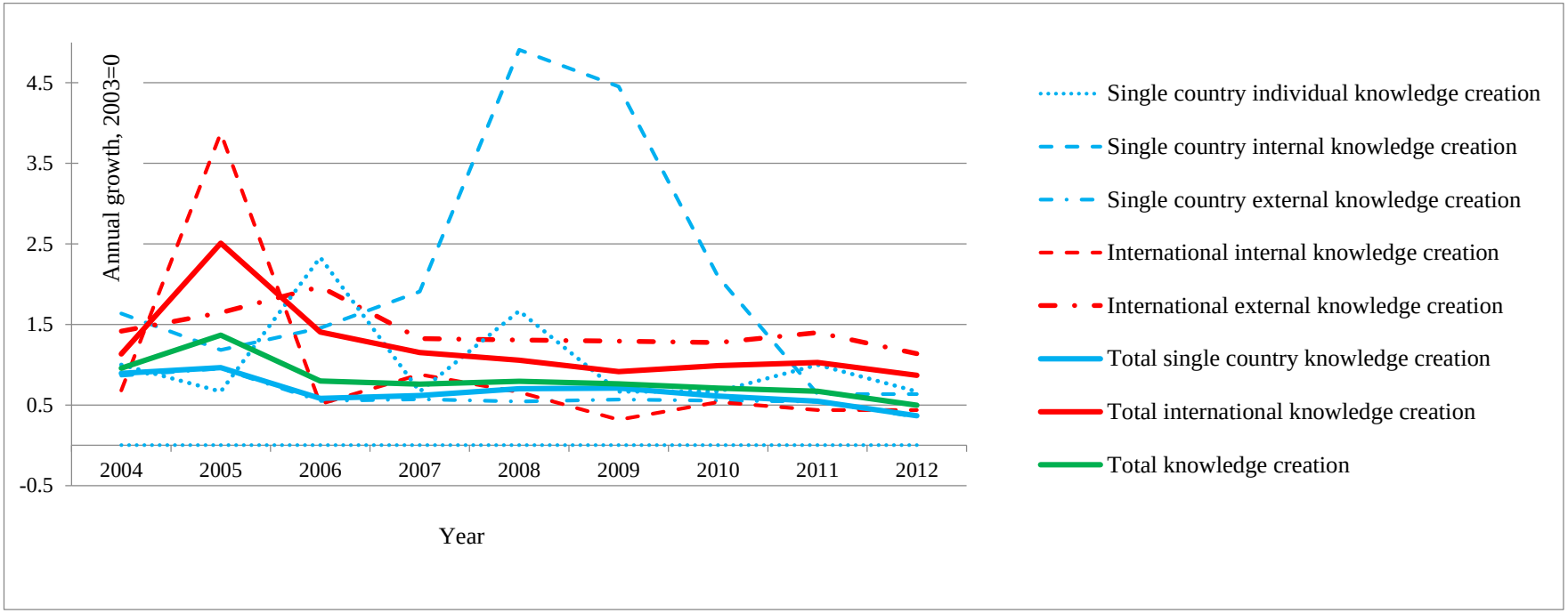
With regards to the locational origins of knowledge creation specifically, the MNE showed a significant share of international, multi-country knowledge creation (38 per cent of all patents), which is above average for the sample used in this research. Also, a greater number of subsidiaries participated in this form of knowledge creation (Figure 3.7.). However, the rate of growth for this type of knowledge compared to base year remained low after a slight peak in 2004 (Figure 3.6.). In absolute terms a dominance of single country knowledge creation remains as 62 per cent of patents are created domestically, which is a similarity to the pattern of Vodafone. However, this type of knowledge recorded a decline throughout the period and in 2012 the level of single country knowledge creation decreased by 64 per cent compared to base year. While in the Vodafone case a significant share of knowledge was created in the headquarters, here we observe a full dominance of subsidiary knowledge creation as 99 per cent of all patents were created outside the headquarters, bringing together location advantages of eleven different country locations. However, we observed that for both MNEs the collaborations were largely with subsidiaries operating in developed countries than with units operating in developing or transition economies.

Based on organisational boundaries, the absolute majority of all knowledge creation was developed in collaboration as mentioned, with single country knowledge creation dominating, but international knowledge creation having an above average share. Higher average growth was recorded for internal single country knowledge creation compared to external in the period, whereas in case of international knowledge, higher average growth was recorded for knowledge with external international partners. In case of international knowledge, 30 per cent

of international patents were developed internally within the MNE with one or more units operating in different countries, whereas the dominating share of 62 per cent was created using external international knowledge creation strategies, beyond the MNEs organisational boundaries. This is very different compared to the case of Vodafone. With regards to domestic, single country collaborations, the type of established partnerships follows a similar pattern as the vast majority of these collaborations is external (55 per cent of all patents), with domestic partners outside of the MNE and, similarly as in case of Vodafone, the number of units participating in these types of partnerships is greater than in case of international knowledge creation (Figure 3.7.). However, the difference is that GlaxoSmithKline engaged significantly more in single country internal knowledge creation with seven per cent of all patents being developed between units operating in the same country environment and this type of knowledge creation was on average 2.1 times higher per year compared to 2003, with peaks in 2008 and 2009 (Figure 3.6.).

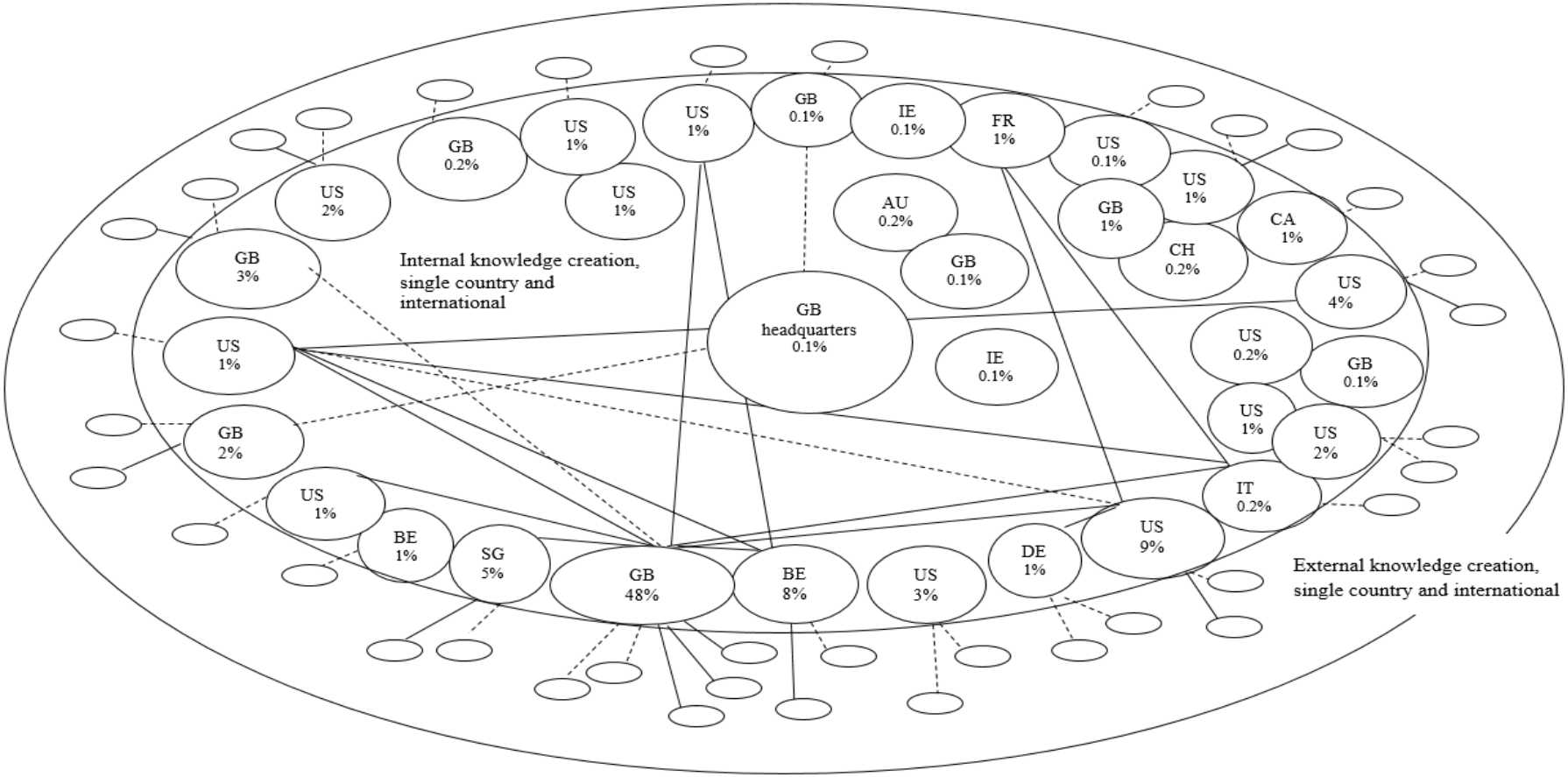
Similarly to the previous case, only a limited number of units engages strongly in knowledge creation considering that three units account for around 67 per cent of all patents. Also, the majority of units create knowledge in form of collaboration, where single country co-operations dominate, but the units also engage in international knowledge creation in an above average number of cases.

Figure 3.6. Knowledge creation with different origin in GlaxoSmithKline PLC annual growth 2004-2012, 2003=0



Note: Based on a sample of 16,143 patents created by GlaxoSmithKline PLC and its first level units in the 2003 to 2012 period. Source: European Patent Office.

Figure 3.7. Locational and organisational origins of knowledge creation in GlaxoSmithKline PLC, 2003 to 2012



Note: The main two circles represent internal or external knowledge creation, both single country and international, while the small circles represent a particular knowledge intensive unit, with a note of the country of operation and percentage share of total patents granted to the unit. The empty circles represent external partners. The full lines represent international knowledge creation, whereas the dotted lines represent single country knowledge creation. Based on a sample of 16,143 patents created by GlaxoSmithKline PLC and its first level units in the 2003 to 2012 period. Source: European Patent Office.

CHAPTER IV

INTERNATIONAL INTERNAL AND EXTERNAL KNOWLEDGE CREATION AND MNE PERFORMANCE

1. INTRODUCTION

A fundamental issue within the field of innovation management is how to create knowledge of high value in a speedy and consistent way in order to cope with short product life cycles and to effectively respond to radical changes in the technological field and sudden shifts in the market (Rigby and Zook, 2002; Tushman and O'Reilly III, 1996). The literature argues that the answer is to look outside for ideas from both internal and external sources as well as from international locations in order to secure access to a plethora of novel and heterogeneous information, build a superior knowledge base and a solid foundation for new knowledge creation, which will enable the firm to stay ahead of the competition (Almeida, 1996; Belderbos et al., 2004; Berchicci, 2013; Chesbrough and Crowther, 2006; Kogut and Zander, 1993; Patel et al., 2014; Rigby and Zook, 2002; Van de Vrande, 2013).

Specifically, studies argue that the advantage lies in the superior capabilities of firms to create knowledge internationally, in cooperation with internal and external partners from different countries, and to develop a global network for knowledge creation (Feinberg and Gupta, 2004; Kogut and Zander, 1992; Kogut and Zander, 1993; Leiponen and Helfat, 2010). Recent studies showed that MNEs are increasingly creating knowledge using international strategies (Berry, 2014; Van de Vrande, 2013) and the empirical evidence used in this study showed that around one third of all knowledge creation is actually international, between partners operating in more than one country, consistent with the growing trend.

By operating in different countries, MNEs in particular have the opportunity to engage in international knowledge creation strategies which provide access to diverse knowledge and ultimately may result with innovations of higher value and significance (Ahuja and Katila, 2004; Almeida, 1996; Florida, 1997; Ghoshal and Bartlett, 1990; Kogut and Zander, 1992; Kogut and Zander, 1993; Pearce, 1999). Although international knowledge creation was traditionally undertaken in order to successfully apply established technology in new countries, that short term limited role has evolved to a more strategic function (Pearce, 1999). Firm are interested in gathering as many ideas as possible from different and distant sources and create new knowledge by using a global network for knowledge creation (Almeida, 1996; Birkinshaw and Hood, 1998; Feinberg and Gupta, 2004; Florida, 1997; Kogut and Zander, 1992; Kogut and Zander, 1993; Kotabe et al., 2007; Leiponen and Helfat, 2010; Pearce, 1999).

Yet, international knowledge creation is the most complex knowledge creation strategy. Not all firms are able to create knowledge internationally or benefit from these strategies (Berry, 2014). International knowledge creation, although appealing, is accompanied by increased governance costs of managing an over-extensive global portfolio of ideas, costs of maintaining the relationships needed in order to pursue these strategies and risk of losing the firm's internal knowledge advantages to partners involved (Belderbos et al., 2010; Kotabe et al., 2007; Leiponen and Helfat, 2010; March, 1991).

Despite the increasing importance of international knowledge creation and the contrasting views about its benefits, fairly little is known about the role that different types of these strategies specifically play for the firm (Almeida, 1996; Kotabe et al., 2007; Singh, 2008). In fact, particular studies point out that evidence on the value of particular international knowledge creation strategies is limited and the conversation is in the initial stage (Almeida, 1996; Kotabe et al., 2007; Singh, 2008). While previous studies acknowledged that firms may create knowledge using single country or international strategies (Berry, 2014), with internal or external partners (Berchicci, 2013; Cassiman and Veugelers, 2006; Grimpe and Kaiser, 2010), and showed that relationships such as manufacturing integration, personnel rotation, R&D co-practice and cross-regional ties support international knowledge creation (Berry, 2014; Frost and Zhou, 2005), studies analysing the performance effect of different international knowledge creation strategies specifically are scarce. What we do not know is whether internal and external international knowledge creation are beneficial for MNE performance and in which way. Therefore, this chapter offers conclusions about the share of performance growth that can be attributed to different levels of different international knowledge creation strategies, which represent the most elaborate and challenging strategies of knowledge creation.

By investigating the value of international internal and external knowledge creation strategies, this chapter extends current conversation on how and why firms open their knowledge creation boundaries to international partners both within and outside the firm. In order to explain the performance effects of different international knowledge creation strategies, this study relies on knowledge of the firm and subsidiary evolution theory supported by insights from interrelated theories. The theories explain possible mechanisms through which internal and external international knowledge creation may affect firm performance (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993), but do not specify the performance effect of these strategies. Also, while recent studies looked at the extent to which firms create knowledge internally or acquire it from external sources and how this affects performance (Berchicci, 2013; Cassiman and Veugelers, 2006; Grimpe and Kaiser, 2010), our approach differs as its focus is on knowledge creation specifically. The question is not whether firms

make or buy knowledge, but whether and why they make it using different international strategies.

Furthermore, previous studies that looked at international knowledge in particular did not scrutinise between different strategies within the concept of international knowledge creation (Alnuaimi et al., 2012; Berry, 2014; Patel et al., 2014). For instance, studies distinguished between single country and international knowledge and therefore took into account the locational origins, but did not differentiate international knowledge further into different strategies based on organisational origins (Alnuaimi et al., 2012; Berry, 2014; Patel et al., 2014). Similarly, studies which recognised knowledge based on the organisational origins did not include the locational origins at the same time (Arora et al., 2014; Frost and Zhou, 2005), which resulted in limited conclusions about their effects. A study looked at internal knowledge creation and referred to it as R&D co-practice, but did not employ information about the locational origin of such knowledge (Frost and Zhou, 2005). In this view, internal knowledge included both single country and international knowledge as one concept.

Moreover, this study explores the performance effect of different international knowledge creation strategies on group level, which differs from studies exploring international knowledge effects on the unit level or on the level of a specific innovation (Alnuaimi et al., 2012; Kotabe et al., 2007; Singh, 2008). Finally, we define international knowledge creation following most recent advances as multi-country knowledge (Berry, 2014), which differs from the traditional view of international knowledge as all knowledge outside the specific country of operation (Almeida, 1996; Kotabe et al., 2007; Lahiri, 2010). In this way we offer conclusions regarding international knowledge as a cross country phenomenon.

The empirical analysis relies on a comprehensive sample of 46,712 patents as indicators of knowledge creation granted to 150 UK headquartered manufacturing MNEs and their 5,352 first level subsidiaries operating in more than 112 different countries during the 2003 to 2012 period. We find evidence that both international internal and external knowledge creation strategies have a U-shaped effect on MNE group performance. Although these effects are consistent with other studies reporting the complex relationship between international knowledge and performance, the direction of the effects is different. While other studies find that excessive international knowledge in general and external knowledge acquisition are beneficial only up to a point (Belderbos et al., 2010; Kotabe et al., 2007), we find that in case of knowledge creation, international internal and external strategies are beneficial for performance beyond a certain point.

2. THEORY AND HYPOTHESES

The literature suggests that MNEs are knowledge creating systems which leverage knowledge and information from both internal and external sources operating in different countries with superior efficiency (Kogut and Zander, 1993). If the MNE makes a strategic choice to create new knowledge in collaboration with at least one partner that operates in a different country, it engages in international, multi-country knowledge creation strategy (Berry, 2014) (third chapter, Figure 3.1., cell 3 and 4).

International knowledge creation differs significantly from single country knowledge creation because it brings together heterogeneous knowledge from different countries in which the partners operate and that knowledge is more likely to be used in subsequent innovations by the MNE (Berry, 2014). When co-creating knowledge internationally, the knowledge of partners involved is recombined and synthesised into new knowledge and their knowledge creation capabilities are reconstructed based on new information accessed (Berry, 2014).

International knowledge creation is the new frontier for knowledge creation. Recent studies argue that the share of international knowledge creation in the overall knowledge creation strategy is growing in importance (Berry, 2014) as consequence of increasing interdependence between different technologies and the growing costs of retaining leadership in a particular technological domain (Narula and Hagedoorn, 1999). Many knowledge intensive industries require interdisciplinary know-how and skills in knowledge creation in order to gain advantages, which adds to the growing costs of innovating and discourages firms from creating new high value knowledge individually (Narula and Hagedoorn, 1999).

2.1. International internal knowledge creation and MNE performance

Subsidiaries play a key role in the process of international knowledge creation. Since each subsidiary, apart from being a part of the MNE network, is embedded in its unique location and therefore has access to the location's specific knowledge, it is a valuable source of information for the whole MNE (Gupta and Govindarajan, 2000; Kogut and Zander, 1993). If the MNE chooses to create knowledge by form of collaboration among subsidiaries which operate in different countries thus drawing from diverse clusters of knowledge, it engages in international internal knowledge creation (Berry, 2014) (third chapter, Figure 3.1., cell 3).

One of the traditional forms of international internal knowledge creation is R&D collaboration between the headquarters and overseas subsidiaries (Frost and Zhou, 2005; Yang et al., 2008). The aim of this strategy is to share and transfer valuable knowledge from headquarters to subsidiaries to ensure that the subsidiary succeeds in a particular market or in form of reverse

knowledge transfer by which subsidiaries transfer valuable local knowledge to the headquarters (Frost and Zhou, 2005; Kogut and Zander, 1992; Kogut and Zander, 1993; Yang et al., 2008).

Although the units may engage in other ways of sharing knowledge (not only internal knowledge creation), for instance through simple communication processes, studies showed that more formal collaborations such as internal knowledge creation are strategies which enable more effective knowledge integration and transfer in the MNE (Subramaniam, 2006). Therefore, international internal knowledge creation specifically may be more valuable to MNEs compared to other more simple strategies.

According to the knowledge based view and subsidiary evolution theory, international internal knowledge creation may impact MNE performance based on two mechanisms: by accessing and combining diverse location specific knowledge held by units which results with knowledge creation of higher value and by building knowledge capabilities of units, both of which will be transferred to the MNE level and build the knowledge advantage of the whole MNE (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993).

Firstly, international internal knowledge creation combines heterogeneous knowledge from two or more different countries in which the units operate (Ahuja and Katila, 2004; Kogut and Zander, 1993; Kotabe et al., 2007; Leiponen and Helfat, 2010). In fact, prior evidence based on international knowledge sourcing showed that sustained superior performance depends on the MNE's ability to combine the scientific and technological know-how available in international locations (Katila and Ahuja, 2002, Leiponen and Helfat, 2010) and transfer and deploy such knowledge of overseas markets within the whole group (Subramaniam and Venkatraman, 2001). Since international internal knowledge creation brings together different ideas and concepts, this knowledge creation strategy will stimulate the creation of knowledge that is higher in value and importance in the MNEs technological field compared to single country knowledge and directly increase performance of the units involved (Kogut and Zander, 1993). These strategies represent an opportunity for the units to overcome limitations related to individual knowledge creation in which the units do not have access to knowledge and information held by other international units. In this way, knowledge created using international internal strategies will be novel and will represent an advantage for the units involved (Barney, 1991; Kogut and Zander, 1993).

Moreover, since international internal knowledge creation involves cross unit collaboration, it also represents an important instrument through which both existing knowledge within units from different locations and the new knowledge created can be transferred throughout the MNE, which enables the positive performance effects to materialise also on MNE group level

(Kogut and Zander, 1993). In this way, knowledge pertaining to one unit and the new knowledge that is created through international internal strategies will be available for exploitation across the MNE (Kogut and Zander, 1993). Also, engaging more in these knowledge creation strategies will give the units opportunity to combine the diverse knowledge further (Kogut and Zander, 1993). Ultimately, the process of accessing, combining and transferring heterogeneous, multi-country knowledge based on international internal knowledge creation strategies across the group will change the global knowledge of the whole MNE which will be more diverse and more available (Kogut and Zander, 1993).

Secondly, international internal knowledge creation builds knowledge creation capabilities of units (Birkinshaw and Hood, 1998). Since international internal knowledge strategies involve building on and combining knowledge from different units and different locations, the subsidiary will as a result have higher capability to create knowledge in the future compared to subsidiaries which engage only in single country and individual knowledge creation strategies (Birkinshaw and Hood, 1998; Kogut and Zander, 1993). Because the units collaborating in these strategies are more familiar with information and models of creating knowledge that other units have, they will enrich their own knowledge capabilities. As more subsidiaries engage in international internal knowledge creation strategies, more of them will have enhanced knowledge creating capabilities which means that the MNE as a whole will be more capable in creating more valuable knowledge in the future and experience higher performance. In this view, international internal knowledge creation is an instrument for transferring and integrating different knowledge-based capabilities within the whole MNE (Kogut and Zander, 1993; Subramaniam and Venkatraman, 2001; Yamin and Otto, 2004).

Although the theories explain the ways in which international internal knowledge may be beneficial for MNE performance, they also suggest that the effects of this strategy may be subject to certain limitations. To ensure that the knowledge accessed and created using international internal strategies is transferable and accessible throughout the MNE it needs to be codified and simplified to some extent (Kogut and Zander, 1992; Kogut and Zander, 1993). Initially the diverse knowledge in international internal knowledge creation will be only available to the units involved which themselves may not be able to fully benefit from it as the cross unit information might not fit their existing knowledge base and might be difficult to understand and utilise (Kogut and Zander, 1992; Kogut and Zander, 1993). The MNE needs to support its codification and simplification which would make the knowledge easier to use easier to use and transfer (Kogut and Zander, 1992; Kogut and Zander, 1993).

The need for codification as a pre-requisite for transferring the knowledge accessed through international internal knowledge creation also means that the MNE needs to devote more

resources in order to simplify that new knowledge which is to be exploited by other MNE units. This suggests that benefiting from international internal knowledge creation is more complex than if the knowledge was created only by one unit. Furthermore, the process of codification and simplification will also make the knowledge easier to understand for external actors and the MNE would be at risk of imitation and may potentially lose the valuable information resulting from these strategies (Kogut and Zander, 1992; Kogut and Zander, 1993). Since the knowledge that is to be transferred only within the MNE will also be more externally available, it might lose its value and the MNE performance effect might be significantly reduced or lost (Kogut and Zander, 1992; Kogut and Zander, 1993).

The studies mentioned above indicate that international internal knowledge creation may result with both positive and negative effects and the exact performance impact may be of a more complex nature. We argue that the potential MNE performance benefits of internal international knowledge creation may not be materialised due to the higher need to codify and simplify the knowledge in order for it to be transferrable. The codifying process will require a higher commitment of resources when the units first engage in these knowledge creation strategies. However, after a certain point at which the subsidiaries have gained experience in this knowledge creation strategy and knowledge sharing between them is easier, the need to codify will become smaller and therefore the costs will be significantly reduced, making the knowledge based on international internal knowledge creation strategies highly transferable, which means that it will be shared across MNE units and recombined into new knowledge more effectively, which will positively affect MNE performance. At this stage, having access to a variety of knowledge and ideas gathered from multiple locations in which the units operate will enable the whole MNE to increase its chances of competing in the respective technological field by creating knowledge that is of higher value. Similarly, engaging in just a few international internal knowledge creation processes may make it challenging for the units involved to implement and exploit the diverse ideas and knowledge they have access to, however after a certain point the units will develop the capabilities needed to become more effective and these capabilities may be transferred across the MNE through further international internal knowledge creation. Therefore, only after a certain point we expect these strategies will result with a significant increase in combinative knowledge creation capabilities of the MNE as a whole.

To conclude, we expect the performance effects of international internal knowledge creation to be negative, but subject to positive returns beyond a certain point. The theoretical arguments lead to the expectation that the slope of the relationship between international internal knowledge and performance will not have the same sign for all values of this knowledge strategy. In other words, we expect the magnitude of the slope to initially decrease as

international internal knowledge creation increases and the magnitude of the slope to increase after knowledge increases beyond a certain point (Cameron and Trivedi, 2009). We therefore hypothesise:

Hypothesis 1: International internal knowledge creation is curvilinearly (U-shaped) related to MNE performance. (H4.1.)

2.2. International external knowledge creation and MNE performance

The geographically dispersed MNE subsidiaries are also embedded in an external network of other organisations both within the location they operate and beyond it which represent potential knowledge creation collaborators (Ghoshal and Bartlett, 1990; Kogut and Zander, 1993; Lavie, 2006). Therefore, international knowledge can also be created through collaboration with external partners (Cassiman and Veugelers, 2006; Chesbrough, 2006; Kogut and Zander, 1993).

Specifically, international external knowledge creation refers to cases in which knowledge is created between one or more MNE subsidiaries and one or more co-creators outside the MNE, which operate in two or more different countries (third chapter, Figure 3.1., cell 4). (Kogut and Zander, 1992). This international knowledge creation strategy transcends the organisational boundary of the MNE and represents a specific interconnected environment through which the MNE can access diverse knowledge resources which are outside the MNE, its units and locations in which the units operate and which transforms the MNE knowledge base (Lavie, 2006; Chesbrough and Crowther, 2006; West and Bogers, 2013). According to the data in this study, international external knowledge creation is the dominant form of international knowledge creation. It can be created through R&D cooperation, strategic technological partnering, joint ventures, mutual exchange or know-how trading (Arora et al., 2001; Narula and Hagedoorn, 1999; Veugelers, 1997).

Although the MNE may access heterogeneous cross-country knowledge by using international internal knowledge creation, the information accessed using these strategies is limited only to the countries that the units operate in, since it is a cross-unit knowledge creation strategy. By using international external knowledge creation strategies the MNE is not limited by the countries the units operate in and can access knowledge held by any external knowledge co-creator and any country the co-creator operates in. In this way, the knowledge MNEs can access using international external knowledge creation strategies is different compared to international internal knowledge creation primarily because it is characterised with a higher degree of diversity. MNEs which use these strategies recognise that not all good ideas can come only from other units and locations the MNE units operate in and that not all high value

knowledge can be created only using internal knowledge creation strategies (Chesbrough and Crowther, 2006). In fact, MNEs must go beyond international internal strategies and leverage the knowledge and discoveries of other external actors which may operate in distant countries that the MNE does not have direct access to through its units (Chesbrough and Crowther, 2006).

According to the knowledge based view and subsidiary evolution theory, international external knowledge creation may impact MNE performance based on two mechanisms: by bringing more opportunities for future revenues and knowledge creation based on the diverse knowledge accessed and by building subsidiary capabilities through greater knowledge creation efficiency (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993).

Firstly, international external knowledge creation, by giving the option to accumulate knowledge and information that the firm would not have access to through other knowledge creation strategies, provides the whole MNE with a platform for future revenue and knowledge creation opportunities (Kogut and Zander, 1993). The units involved will have access to new information beyond the information held in locations in which the units operate and by sharing and transferring that information throughout the group, the MNE is able to use it in identifying valuable knowledge creation opportunities in the future, which will positively affect MNE performance (Kogut and Zander, 1993). It will give the MNE more ideas to choose from and projects to pursue, which will act as a base for new knowledge development. Because new MNE knowledge is often an outcome of recombination (Kogut and Zander, 1993), having access to a variety of different knowledge opportunities which can be recycled throughout the group will have a positive impact on future innovation (Leiponen and Helfat, 2010).

MNEs are especially motivated to access and accumulate knowledge from research intensive locations where peer firms that are leaders in the technological field operate (Cantwell and Piscitello, 2002; Feinberg and Gupta, 2004; Lahiri, 2010). Also, having access to knowledge held in distant locations may protect the MNE's future revenues (Kogut and Zander, 1993). For instance, if a market grows rapidly in a location that the MNE does not have presence in, accumulated knowledge about that market through international external knowledge creation may facilitate the entry into that market and the creation of location specific products, all of which will reduce the market entry costs and risks for the MNE and bring higher revenue and performance (Kogut and Zander, 1993).

Secondly, international external knowledge creation is expected to have a positive effect on subsidiary capacity to use and deploy knowledge creation resources, which will build their capabilities (Birkinshaw and Hood, 1998). Access to diverse knowledge not kept or easily

attained by the MNE and their units will enable the subsidiaries to be more efficient when creating knowledge. Since the subsidiaries will access new knowledge without the need to develop it in-house, international external knowledge creation will lower their fixed R&D costs (Chung and Yeaple, 2008; West and Bogers, 2013; Yamin and Otto, 2004). This effect will be more pronounced in cases when the new knowledge accessed is complementary, where the possibility of combining their internal research efforts and knowledge reservoirs with the new knowledge will enable future knowledge to be created in a speedy manner (Kogut and Zander, 1992). Efficiency in knowledge creation will also materialise as a consequence of risk sharing that is involved in international external knowledge creation. Because the costs of new knowledge creation are shared between the co-creators, the risks are lower compared to, for instance, individual knowledge creation. The resulting advanced knowledge creation subsidiary capabilities will benefit performance on MNE level since the subsidiaries will create new knowledge in a speedy and efficient manner, which will protect the competitive position of the MNE in their respective technological field.

Despite the potential benefits, international external knowledge represents the most complex knowledge creation strategy according to the locational and organisational origins and the theory also points out its possible limitations. The potential challenges depend on the relevance of the international external knowledge strategy to the MNE, its aims, the complexity of relationships it is based on and the possible negative impact on subsidiary capabilities (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993).

Knowledge theory of the firm suggests that MNEs will transfer and build on knowledge that is closely related to their current knowledge base (Kogut and Zander, 1992). If the knowledge they access through international external knowledge creation is distant from their technological field, their chances of building future knowledge on this newly available know-how will equal to that of a start-up (Kogut and Zander, 1992).

Furthermore, MNEs may engage in international external knowledge creation with aims other than to gather knowledge that they would not have access to otherwise. For instance, they might engage in strategic international external knowledge creation. The aim of strategic knowledge creation is to build an extensive knowledge portfolio used to deter new entrants or limit competitor's opportunities for patenting in the field, but it is costly and does not bring direct economic returns in the short run (Artz et al., 2003; Artz et al., 2010; Deeds and Decarolis, 1999). Studies argue that a significant proportion of new knowledge development (especially in form of patents) plays a more strategic role in firm competitiveness and has a defensive nature aimed at restricting a competitor's knowledge creation opportunities in the respective technological field (Artz et al., 2010). If international external knowledge is created primarily with a strategic aim, the immediate and direct positive link between new knowledge

creation and performance, both on unit and MNE level, cannot be realised as the knowledge creation strategy would not bring in new knowledge that is to be transferred and recycled throughout the MNE.

International external knowledge specifically is based on complex cooperative relationships (Kogut and Zander, 1992). Therefore, it requires an effective regulation of these relationships, which may require additional resources compared to other knowledge creation strategies (Leiponen and Helfat, 2010). The more co-creators are involved in the international external knowledge creation and the more the MNE engages in these strategies, the more challenging it will be for the MNE to govern these relationships and knowledge creation strategies.

Although access to diverse knowledge through international external knowledge creation may positively affect the ability of the units involved to create future knowledge, combining knowledge from a variety of locations may also make it difficult for the units to select between the best ideas (March, 1991). This would actually make the units more inert when creating new knowledge and they may lose out as the knowledge creation responsibility would be assigned to another unit (Birkinshaw and Hood, 1998; Laursen and Salter, 2006; Pearce, 1999; Stuermer et al., 2009). In this view, units that engage in international external knowledge creation may actually lose their knowledge creation charter and therefore may not utilise the newly accessed knowledge for future knowledge creation. Also, on MNE level, the possibility that the new knowledge and opportunities based on international external knowledge creation are actually transferred throughout the MNE is diminished because the units lost the opportunity to engage with other units in future knowledge creation. Because the knowledge cannot be fully transferred, the positive MNE performance effect of international external knowledge creation may be reduced.

Based on these mixed theoretical arguments, we expect that the relationship between international external knowledge creation and MNE performance will not be a straightforward one. We argue that MNEs, when implementing international external knowledge creation will similarly experience challenges due to the increase in costs and risks in managing such complex strategies. External international knowledge creation will demand a higher commitment of resources on the firm's part. Furthermore, the firm will face other costs beyond governance such as longer lead time, losses due to the ineffectiveness because of the inflow of new ideas and concepts which the firm cannot see as imminently useful and costs related to time needed to process possibilities based on the new information. However, after a certain point benefits will materialise. Because the MNE has established the cooperative relationships for further international external knowledge creation, the governance costs will be significantly reduced which will bring down the costs of new international external knowledge

creation. Future knowledge sharing and external knowledge acquisition will happen in a more effective way. Also, the MNE will be able to build on the richness of new knowledge now available which will raise the capability for new knowledge creation within the whole group. Moreover, the firm will be able to materialise on the savings made on fixed R&D costs which will be shared between the co-creators and it will be able to complement existing knowledge with the most valuable external ideas and know-how in order to develop new knowledge, all of which will have a positive effect on the performance of the whole group. In conditions of uncertainty, these strategies will give the firm the highest probability of achieving breakthrough innovations and remain competitive. We therefore predict that the performance effects of international external knowledge to be negative, but subject to positive returns after a certain point. The hypothesis is:

Hypothesis 2: International external knowledge creation is curvilinearly (U-shaped) related to MNE performance. (H4.2.)

3. DESCRIPTION OF THE DATA

This research uses firm level data considering it enables the assessment of private returns to knowledge creation, in contrast to industry and country level data which is used to study social returns. Data both on the unit and MNE group level are used as sources for the construction of variables, whereas the analysis is performed on the level of the whole MNE group. The full sample for this thesis takes into account 150 largest firms from the manufacturing sector headquartered in the UK. The reasons for choosing UK headquartered manufacturing MNEs is discussed in chapter one section 1.4.

The observation period for which the information is collected is ten years, from 2003 to 2012. Due to time and data sources limitations, a longer time period was not possible to take into account. When information about a sample of firms is given over time, it represents a panel data structure. Analysing the impacts of knowledge creation strategies of different locational and organisational origins on performance by using a panel dataset has significant advantages compared to other approaches, which are discussed below.

3.1. Advantages of panel data

The advantages of panel data compared to cross section or time series are (Pindado and Requejo, 2012):

(1) Panel data offers a significantly larger number of observations (depending of the number of time periods), which increases the degrees of freedom and may reduce collinearity among explanatory variables, all of which enable a more efficient estimation of variables and model and therefore greater power of generalisation;

(2) Using panel data allows the analysis of hypotheses that cannot be addressed using cross-sectional or time-series data sets. In this case we are determining the impact of knowledge creation strategies of different locational and organisational origins on productivity performance. If we applied cross section data, we could not estimate this effect as we do not have information about the movement of both variables, only observations at one point in time. Using time-series data would not be useful as the aim is to match knowledge creation strategies of different locational and organisational origins and performance of different firms. Also, using a panel dataset enables us to analyse how the relationships of focus may be affected by the specifics of different firms. For instance, we are able to determine whether the effects differ in different industries or in firms which have a different organisational structure;

(3) In a panel data environment the differences between firms in values of independent variables help to reduce the problem of collinearity, which would be present in other data types. Also, it minimises the problem of measurement error which can lead to misspecification of the model. Using multiple observations for a given individual at a given time as in a panel environment enables the identification of an otherwise unidentified model.

(4) The use of panel data also provides a solution for presence of omitted or unobserved variables which are correlated with explanatory variables, and which may lead to not finding the effect which is the research focus. By applying information across firms and over time we are able to control for the effects of unobserved heterogeneity. For instance, firms may differ according to management's attitude with regards to knowledge creation strategies. Some firm's management may have a more positive attitude towards particular strategies of knowledge creation and that attitude is constant over time. Other firms may be neutral. However, this attitude we cannot measure with the data sources used (discussed below), but by using panel data we can control for this unobserved heterogeneity, which would not be possible in a cross section or time series environment. Moreover, not controlling for individual differences between firms would lead to biased results. Using firm specific effects and entering them into the model specification, we are able to take into account the unobserved heterogeneity between firms;

(5) Since panel methodology includes a time dimension, it allows control for macroeconomic effects. Similar as in case of individual unobserved heterogeneity, not controlling for these effects would lead to biased results. Including time dummy variables in the model enables the macroeconomic effects across years to be considered and the risk of biased results is reduced.

(6) There are certain problems that arise in econometrics, which panel data methodology gives a viable solution to. One of the main problems is endogeneity, which refers to the problem when explanatory variables in the model are determined simultaneously with the dependent variable (Pindado and Requejo, 2012). In case of this study, firm performance could be determined simultaneously with different knowledge creation strategies. This problem is deeply rooted in economics literature because in most economic phenomena there are interrelations between dependents and explanatory variables (Pindado and Requejo, 2012). The literature suggests using an instrumental variable method using lagged values of variables to mitigate this problem (Pindado and Requejo, 2012), which is adopted also in this study and explained in detail in sections that follow.

3.2. Data sources

The sample of manufacturing companies headquartered in the UK for the analysis was selected based on the companies' most recent turnover with the added criteria that the MNE created a form of knowledge (patents) within the period of focus (2003 to 2012). To gather the information needed we combined data from two sources widely used in previous studies:

i. *Bureau Van Dijk Fame database*, which lists firms headquartered in the UK and provides their financial data and organisational structure information, used for the same purpose in other recent studies (Arora et al., 2014; Brouthers, 2002; Cui and Jiang, 2012). The full sample consists of 150 multinational firms and 5,352 subsidiaries operating in more than 112 countries.

The database is applicable for this study primarily because it provides a list of subsidiaries with their operating country for each multinational, which is needed in order to match the knowledge creation (patent) information with the organisational structure of each MNE. For each multinational, we derived all first level unit information which served as a base for identifying each patent by each unit and headquarters. We checked for all patents assigned to each headquarters and first level unit of each MNE for the ten year period, following prior approach (Arora et al., 2014).

Secondly, the richness of the financial data available through the source allowed for the testing of various measures of performance on MNE level. The database provided financial information such as turnover, number of employees and assets for the selected firms on MNE level for the period.

ii. *European Patent Office (EPO) Espacenet database* which was used as a source of information for each patent of both headquarters and units. The EPO governs patent applications in 19 European countries and offers free access to more than 80 million patents worldwide from 1836 to present, both for subsidiaries and headquarters. This source has been used in many recent studies on various knowledge based topics (Grimpe and Hussinger, 2014; Hall et al., 2007; Reitzig and Wagner, 2010; Salomon and Jin, 2010; Wagner et al., 2013).

We obtained patent information as proxies for knowledge creation strategies in case of headquarters and each first level subsidiary belonging to each MNE in the given time period and aggregated the data on the MNE level for the final analysis. We took into account each patent developed either in the headquarters or any of the subsidiaries of each MNE from 2003 to 2012.

Using a very novel measure of knowledge creation used in a recent study, patent assignments, we are able to track and analyse the locational and organisational origins of knowledge creation in the MNE (Arora et al., 2014). We were able to therefore answer the question whether the patents originate in a single country or internationally, using individual or collaborative internal or external strategies. The database offered this comprehensive information for each patent for each headquarters and units which engaged in knowledge creation. We only used EPO as a source of patent information since prior studies emphasised that patents from different patent authorities are not comparable to each other and the suggested practice is to use a single patent authority to ensure standardisation (Berry, 2014). Table in Appendix 1 provides information about the sources of raw data for each variable.

3.3. The sample

As previously mentioned, the sample for this research includes 150 largest UK headquartered companies and their first level subsidiaries for which we noted knowledge creation activity in terms of patents granted. The selected period for data collection and analysis is a ten year period from 2003 to 2012. The companies were firstly selected according to their latest operating revenue. To be included in the sample the companies also needed to be operating during the period selected and have presence in at least two different countries. Finally, they needed to engage in a form of knowledge creation during the period. For the purpose of this project we analysed the knowledge creation environment for each patent to determine the nature of their origins.

The full sample includes 150 multinationals and their 5,352 subsidiaries operating in more than 112 different countries, which recorded in total 46,712 patents in the selected period. The

sample includes all first level subsidiaries. Including subsidiaries on other levels for each MNE was not possible due to time constraints in gathering the data. Table in Appendix 2 provides the full list of the firms and their main financial and organisational features and Appendix 3 outlines the detailed name and patent matching procedure used.

3.3.1. Representativeness of the sample

The representativeness of the sample also needs to be considered in order to identify potential biases. There were 1,340 manufacturing companies identified in total in the main database, which had headquarters in the UK and at least one foreign subsidiary. These firms fit the definition of an MNE (chapter one, section 1.4.). Therefore, the chosen sample of 150 accounts for 11.2 per cent of the population of UK headquartered MNEs. The 150 MNEs out of the whole population were chosen based on their latest turnover. Prior literature suggested that larger firms engage in complex knowledge creation strategies, such as external knowledge, more (Van de Vrande, 2013). Appendix 2 lists the MNEs and their basic features. Table 4.1. shows the main characteristics of the sample by looking at percentage share of observations of the main knowledge creation variables by firm size and various industry groupings. The knowledge creation variables are explained in section four of this chapter.

Since the MNEs were chosen based on their latest turnover, it is possible to conclude that the main focus is on large firms, which may represent a source of bias. The majority of the sample, 76 per cent, are large companies with more than 1000 employees, around 15 per cent are companies with 500 to 1000 employees, whereas only 8 per cent of firms in the sample recorded less than 500 employees for the time period (Table 4.1.). However, there is significant heterogeneity within the sample in terms of size. For instance, 23 per cent of firms have less than 1,000 employees. Also, the minimum number of employees for a firm within the ten year period was 20 and the maximum 107,046 (Appendix 2). Hence, the sample includes both smaller and larger firms.

The largest firms account for almost all patents observed (more than 96 per cent), whereas smaller firms engage less in patenting (Table 4.1.), which also may be a source of bias. However, it also permits controlling for other sources of performance growth apart from patenting. There are differences in knowledge creation strategies based on firm size. Smaller firms in the sample prefer single country knowledge creation strategies. Also, the share of international internal knowledge is lower in case of smaller firms, than international external, which shows that these companies prefer external to internal international knowledge creation strategies. Apart from large firms dominating the sample in terms of single country knowledge creation, they also engage more in relative terms in both strategies of international knowledge

creation than small firms. The domination is most pronounced in case of international internal knowledge, where companies of these size account for almost all patents of this type in the sample for the period (Table 4.1.). In case of international external knowledge their share is 98 per cent, with smaller firms jointly accounting for less than two per cent (Table 4.1.).

The firms can also be categorised into major industry groups within the manufacturing sector based on the UK Standard Industrial Classification 2007 (UK SIC 2007) (Office for National Statistics, 2007). Around 58 per cent of all observations are linked to three groupings: manufacture of food, beverages and tobacco products, manufacture of machinery, vehicles and equipment and other manufacturing (Table 4.1.). Manufacture of textiles and leather products, wood and furniture, paper and paper products and manufacture of rubber and plastic products are industries with the least proportion of observations, less than five per cent. Looking at the frequency of firms in specific industries we can conclude that the firms are not evenly distributed across industries within the manufacturing sector and this represents a source of bias and a limitation of the study.

Regarding the distribution of knowledge variables, three sector groupings dominate the sample. Manufacture of machinery, vehicles and equipment accounts for a dominating 46.3 per cent share of all patents, followed by other manufacturing and manufacture of pharmaceutical products. Manufacture of pharmaceutical products, computer, electrical equipment and optical products and manufacture of machinery, vehicles and equipment account for a joint 87.7 per cent share of all international patents for the sample and the period. Apart from the three industries, manufacture of coke, petroleum and chemicals, manufacture of basic metals and metal products and other manufacturing firms also engaged in international knowledge creation, while other groupings have very a small share, below one per cent. Firms in the sample belonging to the textiles industries did not engage in multi-country knowledge creation.

The table also shows particular groupings did not engage in international internal knowledge creation in the period, opting rather for either single country knowledge creation or external international knowledge creation. Only firms in the manufacture of pharmaceutical products and manufacture of machinery, vehicles and equipment extensively created knowledge by collaborating with units located in different countries.

Regarding external international knowledge, particular industries dominate the sample. Manufacture of computer, electrical equipment and optical products and manufacture of machinery, vehicles and equipment jointly account for 70.4 per cent of all observations in the sample. Apart from this grouping, manufacture of basic metals and metal products and

manufacture of machinery, vehicles and equipment follow with a high share of external international patents, which, taking all three sectors together, account for 83 per cent of all patents of this type. Manufacture of pharmaceutical products accounts for 4 per cent and other manufacturing represents 9 per cent of all external international patents.

Finally, in case of single country patents, manufacture of machinery, vehicles and equipment and other manufacturing dominate the sample with a composite proportion of 59.2 per cent. Also, this knowledge development strategy is important for firms belonging to manufacture of coke, petroleum and chemicals, manufacture of pharmaceutical products and manufacture of computer, electrical equipment and optical products.

The industries can also be categorised according to their research activity into higher and lower technology industries (Table 4.1.). This categorisation is based on the R&D intensities within different industries, where higher technology industries were considered as more research intensive (Grimpe and Sofka, 2009; OECD, 2011). The OECD distinguishes four industry groupings within the sector: high and medium high-technology industries and medium low and low-technology industries (OECD, 2011). The division of industries into these groups was established by ranking them according to their average R&D intensity divided by both output and value added against aggregate OECD R&D intensities (OECD, 2011). In this way, industries are classified as belonging to higher categories if they have a higher average intensity for both indicators than industries in lower categories (OECD, 2011). The disadvantage of this characterisation is that it is limited by definition as R&D expenditure is not the only measure of innovativeness (Kirner et al., 2009). The second limitation is that it does not account for intra-sector heterogeneity (Kirner et al., 2009). Studies have indicated that firms in some cases do not follow the sector pattern when developing innovations. Although recent studies emphasise the benefits of firm level analysis of R&D expenditure as base for the distinction (Kirner et al., 2009), due to limited R&D information for the sample within the chosen time period, a firm level breakdown of the classifications was not possible in this case. For the purpose of this research we merge the high and medium high-technology industries into one grouping, higher technology, and medium low and low-technology industries into a lower technology industry group (Grimpe and Sofka, 2009) for two reasons. The main reason is due to the limited number of MNEs in the sample. Also, the difference between the medium-low- and low-technology groups is not fully clear because the R&D expenditure data across countries in these industries is limited, as emphasised by the authors (OECD, 2011).

In total 77 firms were identified as operating in low-technology industries, which means that 73 firms were regarded as operating in high-technology industries. According to the number

of firms, both industry groupings were relatively evenly distributed in the sample. Focusing on the distribution of observations in knowledge creation variables, there are imbalances in the two groupings. In case of total number of patents, a higher 62.1 percentage share belongs to high-technology firms, whereas low-technology companies account for 37.9 per cent of total patents. Moreover, when specific knowledge creation strategies are taken into account we can observe that high-technology firms account for a dominant share of 88.9 per cent of all international patents. Therefore, low-technology firms use international strategies less when creating knowledge. Both strategies of international knowledge creation also follow this pattern. Although this sample structure limits the final generalisation of the results for the whole manufacturing sector, it is expected that the firms in the high-technology grouping engage in more complex knowledge creation strategies, as indicated by prior literature (Lahiri, 2010; Van de Vrande, 2013). A possible response to these limitations of the sample would be to restrict or split the sample and take into account only industries which are more knowledge intensive. However, including the low-tech industries that are less innovative enables controlling for other firm specifics which may significantly affect operational performance and helps with the approximation of the average effect expected across the sector, which is the main aim.

Table 4.1. Knowledge creation strategies by firm size and sector categories, 2003-2012

Percentage of observations (%)	Number of firms (%)	Knowledge creation total (%)	Single country knowledge creation (%)	International knowledge creation total (%)	International knowledge creation, internal (%)	International knowledge creation, external (%)
Size						
<500 employees	8.7	0.9	1.2	0.5	0.02	0.6
500–1000 employees	15.3	2.2	3.0	1.3	0.4	0.9
>1000 employees	76	96.9	95.8	98.2	99.4	98.5
Sector						
Manufacture of food, beverages and tobacco products	23	1.0	1.0	0.4	0.0	0.7
Manufacture of textiles and leather products	4	0.1	0.1	0.0	0.0	0.0
Manufacture of wood and furniture, paper and paper products	3	0.3	0.8	0.4	0.0	0.6
Manufacture of coke, petroleum and chemicals	14	8.5	9.5	1.2	0.8	1.4
Manufacture of pharmaceutical products	4.6	10.6	14.0	22.4	33.7	15.7
Manufacture of rubber and plastic products	4	0.5	0.6	0.1	0.0	0.1
Manufacture of basic metals and metal products	8	5.7	6.1	1.5	0.5	2.0
Manufacture of computer, electrical equipment and optical products	11.3	7.2	8.6	19.5	4.8	28.1

Manufacture of machinery, vehicles and equipment	18.6	46.3	39.2	45.8	51.8	42.3
Other manufacturing	16.6	19.8	20.0	8.8	8.4	9.1
Higher technology industries, total	48.6	62.1	71.4	88.9	91.2	87.6
Lower technology industries, total	51.3	37.9	28.6	11.1	8.8	12.4

Note: Sector assignments are based on UK Standard Industrial Classification 2007 (UK SIC 2007) major manufacturing sector groupings. The higher and lower technology industries were categorised according to R&D intensities within different industries (Grimpe and Sofka, 2009; OECD, 2011).

4. VARIABLES

4.1. Dependent variable

The dependent variable, *MNE performance*, is measured as *Total factor productivity (TFP)*, used extensively in prior knowledge and performance related studies (Driffield et al., 2010; Javorcik, 2004; Liu et al., 2009). In fact, studies emphasised the value of the productivity method in particular in panel data studies of private returns on performance based on knowledge (Hall and Mairesse, 1995). TFP is operationalised as the combined residual of a Cobb-Douglas production function, consistent with prior studies of knowledge and performance (Adams and Jaffe, 1996; Griliches, 1992; Kafouros et al., 2008; Liu et al., 2009; Scherer, 1982), taking into account factor inputs of capital and labour as determinants of output. TFP reflects the efficiency with which the MNE uses a given set of inputs to create and appropriate value. Specifically, it is a parameter which governs the relationship between capital, labour and output traditionally identified with technological change, but can include different factors including knowledge (Sargent and Rodriguez, 2001).

Performance of the firm can be measured using various indicators and approaches (Richard et al., 2009), such as financial indicators (ROE, ROA, Tobin's Q) (Tanriverdi and Venkatraman, 2005), market based performance (Deeds and Decarolis, 1999), productivity indicators (Hall and Mairesse, 1995; Griliches, 1979; Griliches, 1998a), innovativeness (Ahuja and Katila, 2001) or subjective measures based on manager's perceptions (Gibson and Birkinshaw, 2004).

However, operational productivity estimated using the production function framework is the most suitable measure in the context of the current study for several reasons. Firstly, it provides the opportunity to estimate statistically the share of productivity increase that can be attributed to knowledge creation strategies (Griliches, 1979), which is the main aim of this research. Secondly, it captures the benefits of both value creation and appropriation from knowledge and innovations, which is superior compared to measures relying on innovativeness which are limited in scope as they do not capture value appropriation fully as they focus on examining a very specific and therefore limited performance indicator. Also, productivity measures rely on both firm outputs and value of inputs and in this way capture variations resulting from accessing location-specific knowledge assets such as cheap scientific talent and also the value that the firm gains by exploiting its knowledge base and redistributing its resources. Moreover, financial measures are volatile and may take negative values (especially related to the time period selected due to the global crisis), do not take into account increases in performance due to technological spillovers, and are subject to problems associated with accounting standards (Richard et al., 2009). Finally, the impact of knowledge may not be reflected in financial indicators in a timely fashion, whereas productivity based

measures are able to capture the short term impact of new knowledge, which is the aim of this study. Productivity levels are also more robust to market fluctuations, transfer pricing, and exchange rate variations compared to other measures.

Apart from this measure we also use other indicators of performance to check for comparability of the parameters. To control for the results given by TFP models, we also test the effects of knowledge creation strategies on *Labour productivity*, represented by output per unit of labour and two financial indicators: *Turnover (Sales)* and *Operational profit*. Labour productivity is especially useful as a control for TFP in cases where there might be biases in constructing or reporting the capital or assets indicator, which is used in estimating TFP (Sargent and Rodriguez, 2001). Since labour productivity is estimated directly using output and labour inputs, these biases are mitigated. Finally, this measure is more effective than TFP when analysing performance during a shorter time period (less than ten years) (Sargent and Rodriguez, 2001). The time period selected for this research is ten years, which makes the TFP indicator applicable, however controlling for labour productivity will make the results more robust. Using accounting measures of firm performance such as turnover and operational profit have specific advantages as they are easily available as well as replicable and their validity in explaining economic returns and distinguishing performance between firms across time periods has been found in many studies (Richard et al., 2009).

4.1.1. Estimating TFP

To obtain this indicator, an established method in the literature was used which focuses on developing a production function from which TFP levels for each firm can be estimated (Temouri et al., 2008). In this way, the potential productivity differences between firms could be identified, as well as the value of different types of knowledge as determinants of productivity.

We estimate productivity as a production function, which represents a relationship between inputs *X* and output *Y*. Following prior studies, we assume that the production function can be defined by a transformation of the Cobb-Douglas model which takes into account knowledge as input (Griliches, 1998a; Hall and Mairesse, 1995; Kafouros et al., 2008).

To obtain values of total factor productivity (TFP) we initially estimate the production function (1) and secondly obtain the residual of the production function which represents TFP (2). The approach follows standard methodology where the models are (Javorcik, 2004; Temouri et al., 2008):

$$Y_{it} = a_Y Y_{it-1} + a_K K_{it} + a_L L_{it} + a_T T_t + a_I I_t + \varepsilon_{it} \quad (4.1.)$$

where subscripts i and t refer to firm and year.

Y_{it} represents the dependent variable and refers to the turnover (in logarithmic form), which is calculated by adjusting the reported sales for changes in the value of the currency (Javorcik, 2004). Y_{it-1} is the first lag of the dependent variable, K_{it} represents capital defined as the value of deflated fixed assets for the respective year, in logarithmic form. L_{it} represents labour measured as total number of employees for the respective year, in logarithmic form. $a_T T_t$ and $a_I I_t$ refer to time and industry dummies. The residual of this equation is the firm specific TFP, represented by ε_{it} (Temouri et al., 2008). To deflate all monetary values we follow standard methodology and use the appropriate deflator index taken from UK Office for National Statistics (Treasury, 2014).

The literature suggests various methods for estimating the above model. Firstly, simple ordinary least squares (OLS) regression is a possibility, but tends to yield less satisfactory and biased parameter estimates when trying to control for endogeneity (Blundell and Bond, 2000). Endogeneity problem may arise because of unobserved heterogeneity in case of omitted variables, simultaneity or measurement errors where there is discrepancy between the true variable and proxy. It refers to the cases when variables are not strictly exogenous because they are correlated with the error term (Pindado and Requejo, 2012). The simultaneity and reverse causality problem arises when a part of the TFP will be observed by the firm at a point early enough to allow for changes in the factor input decision, which implies that the error term of the production function will influence the choice of factor inputs and there will be correlation between the error terms and the explanatory variables in the estimation equation (Arnold and Hussinger, 2005; Blundell and Bond, 2000). Also, endogeneity may appear in cases when explanatory variables are determined simultaneously with the dependent variable (Pindado and Requejo, 2012). Finally, it may be the case that very strong firms in the sample that perform well use specific strategies of knowledge creation. All of these reasons make the OLS estimates of TFP biased.

Olley and Pakes (OP) derived an estimate which solves the simultaneity problem. The estimate uses investment to proxy for the unobserved time-varying productivity shock (Olley and Pakes, 1996; Yasar et al., 2008), but it requires a dataset in which firms also exit from the market, which is not the case in this sample. Because of the short time period of focus and the specifics of the sample, all firms in the sample remained active throughout the period. Also, one of the limitations of this approach is that it requires firms to make positive investments every year, which may not be the case and it would cause the loss of a large number of observations (Temouri et al., 2008). Although Levinsohn and Petrin (LP) resolved the latter issue and proposed using material inputs as a proxy to control for unobservable productivity shocks (Levinsohn and Petrin, 2003; Temouri et al., 2008), because of firm exit issue we use system generalised method of moments (GMM) to estimate the production function (1). Recent

literature showed that using system GMM is reliable and solves the simultaneity problem in production functions (Blundell and Bond, 2000; Wooldridge, 2009). Also, system GMM estimation has shown to be particularly useful for production functions based on short time periods (Blundell and Bond, 2000). The advantages of this approach are discussed in detail in section six.

4.2. Independent variables

The main independent variables used in this chapter are knowledge creation measures, specifically internal and external international knowledge creation. We account for the different knowledge creation strategies using patent assignment information. Before discussing the operationalization of the independents, the next sub-section considers the validity of patents as proxy measures of knowledge creation.

4.2.1. Advantages of patents as proxy measures of knowledge creation

A patent is a legal document issued by an authorized governmental agency which gives the holder (usually the inventor) the right to solely utilise the new device or process which is the subject of the patent for a certain time period (Griliches, 1998b). Patents account for the net accretion of economically valuable knowledge and were used as proxies in other knowledge based studies for a few reasons (Arora et al., 2014; Griliches, 1998b):

- Firstly, patents are one of the most accessible knowledge related indicators, they are a record of knowledge creation activities by definition and patent information available in the databases is based on worldwide standard, which makes studies founded on this measure replicable and directly comparable;
- Secondly, patent statistics provide a viable measure of the output of knowledge creation activity by representing a minimal quantity of newness required by the patent office. Since the process of patenting includes the novelty analysis of the item as the main criteria for issue of this document, it captures the knowledge creation activity of MNEs. Prior studies statistically proved that patents are an outcome of knowledge creation activity and can be used as proxy measures of it (Pakes and Griliches, 1984). Also, patents demonstrate the minimal investment of resources by the inventor or firm into the development of the novel product or idea showing commitment to its utility for the individual or firm;
- Thirdly, patent information available in databases describes with scrutiny the knowledge creation strategy used to develop the patent, which is the main focus of this research, and

- Finally, patent based measures are replicable and can be applied to large samples throughout many years, enabling panel data collection and analysis, which makes the generalisation more reliable.

Moreover, patents are particularly appropriate also for the purpose of this study as they allow a detailed analysis of the specific strategies that MNEs and their units use to create knowledge. The right embedded in the patent can be assigned to the individual inventor, the firm where the invention was created and to groups of firms and/or individuals which jointly developed the innovation (Griliches, 1998b). In this way, patent information gives the exact description of whom the innovation is assigned to (Arora et al., 2014). This information was used to determine the locational and organisational origins of the specific patent, which is central for this thesis. It was used in a similar way in a recent study (Arora et al., 2014).

Patent assignment information, compared to other potential measures, shows in much more detail the strategy of knowledge creation. For instance, using research and development data only shows the firm's inputs in form of resource commitments towards developing new innovations and it does not provide information about the strategy or origin of knowledge creation in MNEs (Griliches, 1998b). This comprehensive view is available by analysing patent assignment information.

4.2.2. Disadvantages of patents as proxy measures of knowledge creation

Using patents as proxies for knowledge creation has certain drawbacks which have been recognised and discussed extensively in prior literature:

- Firstly, patents do not measure all knowledge creation activity a firm might undertake. Not all innovations are patented and not all innovations are patentable (Griliches, 1998b). Since these effects differ across industries, the literature suggests using industry dummies to partially resolve this issue when the sample includes various industries (Griliches, 1998b). This research takes this issue into account and controls for different industries in the models used. However, it is limited as it does not measure other knowledge creation activity.
- Secondly, patents differ according to their technical significance and economic utility (Griliches, 1998b). Some patents represent incremental innovations and attribute only slightly to performance of a firm, whereas others reflect major advancements in the field, significantly affect performance and represent a basis for competitive advantage (Griliches, 1998b). The literature suggested a solution based on the process of weighting patents (Griliches, 1998b), usually by tracking its subsequent citations. If patents were highly cited, they are considered as more valuable. Other studies rely on

the law of large numbers and argue that the relevance of any sampled patent can be interpreted as a random variable with a probability distribution, so the important question was whether actually the sample was large enough to fit this condition (Griliches, 1998b).

The process of weighting patents and accordingly of the knowledge created was beyond the scope of this research because of two reasons. Firstly, it was unfeasible due to time constraints and secondly the time period taken into account is a recent one and the question of the timeline for citations emerged. For instance, consider two patents which we assume are valuable. Much more time has passed for a patent granted in 2003 than for a patent granted in 2012, and therefore we can assume that not enough time has passed for the 2012 patent for its economic significance and applicability to be fully utilised compared to the patent from 2003.

- Thirdly, the patent assignment information may not fully reflect the reality of the strategy used to create the patent. For instance, a unit may have the responsibility of working partially or exclusively on the creation of knowledge, but the patent is assigned fully to the headquarters, without giving recognition to the unit which was involved in development of the innovation. In these cases, our conclusions about the origins of knowledge creation can be misleading.

  However, a previous study using the same measure has showed through interviews that patent assignment information effectively follows the real delegation of knowledge creation (Arora et al., 2014), mitigating the potential biases caused by this limitation. The study matched the knowledge creation strategies given by the patent document and the information regarding the strategy of knowledge creation for specific patents obtained directly from firms and concluded they are comparable, which indicates that this limitation has minimal influence on the reliability of data regarding knowledge creation origins and environments used in this study.
- Furthermore, changes in organisational features of a firm might influence the reliability of the patent data. For instance, firms may change their name or make organisational changes due to mergers and acquisitions. These cases may cause technical problems in data collection and for instance, it may happen that we under-assign the number of patents to a specific firm because it undertook name changes in the specific period in which case the knowledge creation analysis will be incomplete and biased (Griliches, 1998b). The Fame database used in this study, however, gives information whether a specific firm has changed its name and therefore we were able to determine whether specific firms have patented under a different name, which provided the opportunity to mitigate this drawback.

In conclusion, we argue that the patent assignment information, although it has limitations, gives detailed and reliable data regarding knowledge creation of MNE headquarters and subsidiaries. It enables the specification of knowledge creation of different locational and organisational origins, which ultimately makes this proxy most suitable for the aims of this research. The next sub-section discusses the operationalization of independent variables.

4.2.3. International internal and external knowledge creation

We first identify the sample of UK headquartered MNEs and their first level subsidiaries. This organisational structure information enabled us to search the EPO database for all patents granted and assigned to the headquarters and subsidiaries in the 2003 to 2012 period. Following prior studies, we identified the patents belonging to the sample by comparing the applicant names and addresses as stated on the patent document to the names and addresses of firms in Fame database, and in this way matched the patents belonging to a particular subsidiary and MNE headquarters (Arora et al., 2014). In total 46,712 granted patents were identified for the time period and the sample.

After the patents were identified, we followed by examining the locational and organisational origins of each of the 46,712 patents. The initial distinction was made between patents with either individual or collaborative organisational origin, following prior literature (Berry, 2014; Frost and Zhou, 2005; Yamin and Otto, 2004). The individual patents were evidenced by just one unit or headquarters named on the patent document as applicant. Each of the individual patents was of single country locational origin.

Collaborative patents were evidenced by more than one applicant named on the patent document. We analysed both the exact location of the partners as well as their organisational affiliation. The address of the applicants enabled us to identify whether the knowledge was created using single country or international strategies. If applicants were located in the same country, the patent was considered as single country knowledge creation and if they operated in more than one country the patent was international.

We continued by identifying the organisational origins of collaborative patents. We based the analysis of organisational origins on comparing and matching the applicant names and country codes on the patent document with all subsidiaries of the MNE, not only the first level subsidiaries, in an attempt to provide the most accurate account of knowledge creation origins. If the additional applicant(s) name and country matched a subsidiary, then the patent was considered as internal knowledge creation. If the additional applicant(s) name and country did not match a subsidiary or was an individual, the patent was considered as external knowledge creation. This process allowed for distinguishing between the single country and international

patents which were developed among units belonging to the same MNE and those created in collaboration with external partners outside the MNE.

Our main focus is international knowledge creation, which we measured as all patents created in collaboration between co-creators from at least two different countries, following prior literature (Berry, 2014). As described previously, international knowledge creation can be internal or external, depending on whether the co-creators belong to the same MNE or not. Both strategies of international knowledge creation are measured in a similar way using patent assignment information as mentioned above (Arora et al., 2014; Berry, 2014).

The first hypothesis predicts a relationship between MNE performance and international internal knowledge creation. The variable *International internal knowledge creation* was estimated by counting the patents created within the MNE as collaboration between two or more units operating in at least two different countries for the specific period, for each unit and headquarters of the same MNE, similar as in prior studies (Berry, 2014). We average the figure first by dividing it by the total number of international patents in the focal unit, giving us a unit level ratio. The outcome shows the share of internal international patents for each unit. In this way, each unit for each of the time periods had a specific share of international internal patents created. Since this is still a unit level ratio and we are interested in measuring its effect on performance of the whole MNE group, a MNE level figure was needed. To obtain this, we sum the ratios of the units and headquarters and divide them by the number of knowledge creating units in the MNE to obtain an MNE level, consolidated measure which shows the average number of internal international knowledge creation for each MNE for each year. The operationalization is as follows:

$$IIK_{it} = \frac{\sum_{it} \left(\frac{IIP_{ut}}{IP_{ut}}\right)}{U_i} \quad (4.2.)$$

where IIK_{it} represents the international internal knowledge creation measured on MNE level, IIP_{ut} is the number of international internal patents for specific unit in a specific period, IP_{ut} is the total number of international patents for the unit and U_i is the number of knowledge creating units in the period (units which recorded one or more patents in the period).

International external knowledge creation is measured similarly, using the count of patents created between one (or more) units belonging to the same MNE and at least one external partner, for each unit and headquarters, IIP_{ut} . Also, the collaborators need to operate in at least two different countries. The variable can be expressed as:

$$IEK_{it} = \frac{\sum_{it} \left(\frac{IEP_{ut}}{IP_{ut}}\right)}{U_i} \quad (4.3.)$$

where IEK_{it} represents the international external knowledge measured on MNE level, IEP_{ut} is the number of international external patents for specific unit in a specific period, IP_{ut} is the total number of international patents for the unit and U_i is the number of knowledge creating units in the period. The resulting measure represents the consolidated average of international external knowledge creation for each MNE and year within the 2003 to 2012 period.

4.3. Control variables

Apart from the independent variables mentioned, other indicators of MNE performance which appeared in prior studies as significant determinants of firm performance were introduced in the model. Firstly, the logarithm of *Total assets* and *Number of employees* were used in the production function to obtain the dependent variable, adjusted for inflation, following prior studies (Javorcik, 2004; Temouri et al., 2008). Studies mostly found a positive and significant effect of both variables on firm turnover (Bloom and Van Reenen, 2002; Javorcik, 2004) and a positive effect is expected in this study.

Furthermore, *Product diversity* and *Number of countries* were included as measures of international diversification, both of which were identified by prior studies as indicators of performance (Tallman and Li, 1996). Product diversity takes into account the number of industry segments in which the firm operates. Due to data unavailability regarding the exact sales figure for each firm's segment, we were not able to employ a Herfindahl-type index (Tallman and Li, 1996). We use the number of different operating industries of the headquarters and units as proxy. Studies have found a positive effect of this control on performance, negative effect or in some cases reverse U-shaped effect, depending on the study (Lu and Beamish, 2004; Tallman and Li, 1996). The number of countries, controlling for internationalisation or the geographical scope of international operations, was measured following prior literature as the number of different countries in which subsidiaries of an MNE operate (Tallman and Li, 1996). The effect of this variable is also mixed, as it shows insignificance in some models, but also negative or positive effects in others, subject to the research context (Lu and Beamish, 2004; Tallman and Li, 1996).

We introduce *Single country patents* as a control for one country knowledge creation, expressed as a MNE level ratio similar to the operationalization of the independent variables explained above. The number of single country patents for specific unit and headquarters in a specific period, SP_{ut} is divided by the total number of patents for the unit, P_{ut}, to obtain a unit level ratio. Finally, the resulting figure is divided by the number of knowledge creating units in the period, U_i , and the final MNE level figure for each year of observation is estimated. The expression is:

$$SK_{it} = \frac{\sum_{it} \left(\frac{SP_{ut}}{P_{ut}}\right)}{U_i} \quad (4.4.)$$

Prior empirical evidence on the effects of patents on firm performance is largely mixed. Many studies argue for positive effects, but some studies found negative impact (Artz et al., 2010; Bloom and Van Reenen, 2002; Deeds and Decarolis, 1999).

In order to control for other knowledge based resources that may impact performance, we use *Intangible Assets* variable, which has been used in prior studies to take into account the effects of assets such as copyrights and trademarks (Hall, 1993). Since it is in monetary form, we also adjust it for inflation. Prior studies noted a positive performance effect (Delios and Beamish, 2001). Furthermore, we also control for *Age* expressed as years of operation and *Size* as median of sales dummy, following many prior knowledge and performance studies which recorded either positive or negative effects for the variables, depending on the context of the study (Lyles and Salk, 1996; Nieto and Rodríguez, 2011). Age of the firm proved to be negatively or positively related to performance or insignificant conditional on context, whereas firm size showed positive effects or insignificant, depending on the model applied (He and Wong, 2004; Lyles and Salk, 1996; Tallman and Li, 1996).

Finally, following established methodology, we introduced dummies to control for the effects of *Time* and *Industry* across all models (Temouri et al., 2008). The main industry of the whole MNE group was taken into account to control for the specific industry effects. The Fame database reports a multinational group's main operating industry, which was taken as proxy for this variable.

5. MODEL

The first step is estimating the productivity function (expression 4.1.) in an attempt to identify potential productivity differences following established methodology (Temouri et al., 2008). As mentioned in section 4.1.1., we apply system GMM to obtain estimates of TFP. System GMM method was recently argued as appropriate in productivity functions as it solves the problem of endogeneity. Prior research showed that labour and other inputs in the production function cannot be treated as exogenous as they are determined based on the firm's productivity and known to the firm but not the researcher (Hall and Mairesse, 1995; Javorcik, 2004). Since the main dependent variable is TFP, it is essential to consider the issue of endogeneity to obtain consistent estimates.

System GMM permits a model based on endogenous dependent and independent variables, as well as variables which are strictly exogenous, in this case year and industry dummies

(expression 4.1.) and it is applied to specify the residuals which represent TFP. In system GMM, the lagged values of the variables that are not strictly exogenous are used as instruments and this process resolves the problem of endogeneity (Pindado and Requejo, 2012), discussed in detail below.

In the second step we introduce determinants of the TFP estimate (expression 4.5.). The empirical model has to capture firm-specific idiosyncrasies and associate variations in productivity at the MNE level with knowledge based indicators, also measured on the MNE level. We used the logarithmic form of the variables to increase the interpretability of the results. The approach follows standard methodology and the full model is (Javorcik, 2004; Temouri et al., 2008):

$$\varepsilon_{it} = \beta_0 + \beta_1 \varepsilon_{it-1} + \beta_2 IIK_{it} + \beta_3 IIK_{it}^2 + \beta_4 IEK_{it} + \beta_5 IEK_{it}^2 + \beta_6 SK_{it} + \beta_7 Pd_i + \beta_8 C_i + \beta_9 IA_{it} + \beta_{10} A_{it} + \beta_{11} S_{it} + v_{it} \quad (4.5.)$$

where ε_{it} is the TFP estimate, IIK_{it} , IIK_{it}^2, IEK_{it} and IEK_{it}^2 refer to international internal and external knowledge creation variables and their squared values, SK_{it} is single country knowledge, Pd_i is product diversity, C_i is the number of countries in which the MNE operates, IA_{it} are intangible assets, A_{it} signifies age, S_{it} refers to size and v_{it} is the error term, i refers to MNE and t to the time period. The model also includes industry and time dummies, but for simplicity reasons we do not include these in the expression.

Both models (4.1) and (4.5) are estimated using system GMM for a few reasons:

- Using OLS may yield inconsistent and upward biased results in presence of individual heterogeneity which appears because each firm has its own specific characteristics which are constant over time and in which case panel models are more appropriate (Pindado and Requejo, 2012). Using panel models allows for the firm specific effect to be included which controls for unobservable individual heterogeneity (as discussed in section 4.1.) (Pindado and Requejo, 2012).
- Fixed effects (FE) and random effects (RE) models are the basic panel data analysis methods used in many prior studies, the choice of which depends on the model itself and how efficient they appear to be when compared, for instance using the Hausman test (Cameron and Trivedi, 2009). FE or within group estimator is not appropriate as the model includes time-invariant regressors (such as industry and product diversity) and also because specific time-varying regressors vary little over time (such as size) which will make the FE estimator imprecise (Cameron and Trivedi, 2009). Furthermore, the results of the Hausman test for the basic model show that RE estimator or between groups estimator is more appropriate. The results of the test are

presented in Appendix 4. Also, we expect that differences across firms have influence on the dependent variable, which makes RE more appropriate. Additionally, this estimation permits the inclusion of time-invariant regressors.

- Although RE controls for unobservable heterogeneity, it does not control for problems of endogeneity (discussed also in section 4.1.1.) and therefore the resulting estimates based on this method can be biased (Pindado and Requejo, 2012). For instance, causality may be present from independents to the dependent, but it also may be the case that firm's knowledge strategy will be determined by the firm's performance, which means that a problem of endogeneity in form of reverse causality might be present. If these endogeneity issues are ignored, the estimates may not be reliable. The literature suggests using an instrument variable method to solve this issue (Pindado and Requejo, 2012).
- If there are no natural instruments for the endogenous variables, the literature suggests using lagged values of the endogenous variable, which is possible in GMM estimators (Pindado and Requejo, 2012). In this case it was difficult to identify potential natural instruments with the data available and therefore, to resolve the endogeneity problem, a GMM estimator is used.
- Two mostly used GMM estimators are difference and system GMM (Pindado and Requejo, 2012). However, the difference GMM is subject to a weak instrument problem and system GMM is more powerful and efficient as it permits the introduction of more instruments (Pindado and Requejo, 2012). Also, in panel data setting with few time periods and many groups and independent variables which are not strictly exogenous, the literature suggests using system GMM to perform the analysis (Pindado and Requejo, 2012; Roodman, 2009). This method also permits inclusion of predetermined not strictly exogenous variables, such as lagged values of the dependent variable which improves specification (Gómez and Maícas, 2011; Roodman, 2009). Recent studies which focused on knowledge or firm performance also applied this method (Gómez and Maícas, 2011; Hillier et al., 2011). In conclusion, the main advantage of system GMM is that it controls for individual heterogeneity and resolves the endogeneity problem because it permits using lagged values as instruments, which yields consistent estimates (Roodman, 2009). Due to these reasons, the most appropriate estimation method for this particular study is system GMM.

Specifically, the system GMM method includes the following main assumptions regarding the data (Roodman, 2009):

- Current values of the dependent variable are influenced by its past values.

As in prior literature, we assume that the current value of TFP is not strictly exogenous (Roodman, 2009).

- Presence of fixed individual effects which are accounted for by using a panel structure.

  Using a ten year panel structure we control for unobserved heterogeneity and take into account the possible firm specifics that are not directly measured, but may impact performance.
- Particular independent variables may be endogenous.

  Following prior literature, we assume that both capital and labour are endogenous (Hall and Mairesse, 1995; Javorcik, 2004) and instrument them in the models. We also assume that intangible assets are not strictly exogenous. Furthermore, based on Hansen test of exogeneity of instrument subsets, we assume particular knowledge based independents are not strictly exogenous.
- Heteroskedasticity and serial correlation may be present.
- The disturbance or error term is uncorrelated across individual firms in the sample.
- External instruments are not available.

  Due to the lack of appropriate natural instruments in the available data as well as time constraints in identifying and collecting them, we use lagged instruments available in the dataset. We follow the instrument structure and system GMM model application as suggested by Roodman (2009). In general we put every independent variable into the instrument matrix. If exogenous then is instrumented by itself, if presumed predetermined and not strictly exogenous then we use lags 1 or longer as instruments (Roodman, 2009). Generally we use the closest lags as instruments, following the literature (Roodman, 2009). For the dependent variable suspected to be endogenous we use lags 2 or longer as instruments as suggested by prior studies (Roodman, 2009).

Although the literature discussing system GMM emphasises its many benefits, it also mentions as disadvantage that it is more complicated than other methods and needs to be implemented correctly in order to generate the most reliable parameters (Roodman, 2009). However, studies also give recommendations to ensure its proper use and it is adopted here. For instance, literature recommends it to be used on short panels, time dummies should be included and every regressor needs to be included in the instrument matrix in some form even if strictly exogenous (Roodman, 2009), all of which is adopted in the modelling and analysis stage.

6. SUMMARY STATISTICS

Table 3 presents the descriptive statistics and correlations. The correlations are given using logarithmic values of the variables, whereas the means and standard deviations are expressed using original values of the variables. The mean of turnover (GBP) is 1174993, with a standard deviation of 1952274. The mean of total assets (GBP) is 758396.5, with a standard deviation of 1597382, whereas the mean of labour in number of employees is 7564.07, with a standard deviation of 16115.88.

In case of the main independent variables estimated using patent assignment data, the mean of international internal knowledge creation is .002, with a standard deviation of .021, whereas the mean of international external knowledge creation is .012, with a standard deviation of .034. The low means of both independent variables indicate that many firms in the sample did not apply or engaged only moderately in international knowledge creation activities, whereas particular firms showed high knowledge creation activity. This is discussed in the representativeness of the sample part of the chapter (section 3.3.1.).

The correlation matrix shows that total assets and number of employees are positively and significantly related to turnover as expected ($p<.05$). The main independent knowledge based variables show a negative and significant association with turnover. They are also correlated, which indicates caution regarding multicorrelation in the model. Out of the control variables, positive and significant relationship with turnover is observed in case of product diversity, intangible assets and size variable, while number of countries in which MNE operates appears to be negatively correlated with turnover.

Table 4.2. Summary (mean and S.D.) and pairwise correlation statistics (* denotes significance level<.05)

		Mean	Standard deviation	1	2	3	4	5	6	7	8	9	10
1	Turnover	1174993	1952274										
2	Total Assets	758396.5	1597382	.32*									
3	Number of Employees	7564.07	16115.88	.17*	.13*								
4	International patents, internal	.002	.021	- .15*	.01	.24*							
5	International patents, external	.012	.034	- .08*	.01	.29*	.32*						
6	Single country patents	.341	.461	-.19*	- .05*	.22*	.02	.24*					
7	Product diversity	9.73	10.99	.07*	.10*	.50*	.22*	.32*	.22*				
8	Number of countries in which MNE operates	7.91	11.56	- .14*	- .08*	.43*	.24*	.33*	.26*	.44*			
9	Intangible Assets	291577.2	1247902	.30*	.40*	.31*	.05*	.11*	.01	.25*	.01		
10	Age	50.53	33.28	-.01	.02	- .04	- .07*	- .03	- .04	- .01	- .16*	- .10*	
11	Size (dummy)	.5	.50	.61*	.18*	.19*	- .05*	- .01	- .05*	.09*	.08*	.24*	- .01

7. RESULTS

Table 4.3 shows the effects of both international internal and external knowledge creation on total factor productivity as dependent variable. Firstly we obtained the TFP estimate, using procedure explained in section 4.1. The model specifications are presented in column one. Secondly, we introduce determinants of productivity. To test the first two hypotheses, we estimated model (4.5.) using the procedure explained in section six. The results of the full model are presented in column 4, Table 4.3. Column 2 presents the baseline model without the main independent variables whereas column 3 shows the results of a reduced model excluding the squared values of the main independent variables, both of which were estimated following established practice.

Hypothesis one (H4.1.) suggests a U-shaped relationship between international internal knowledge creation and MNE performance. The results presented in column 4, Table 4.3. confirm the hypothesis and show that international internal knowledge is curvilinearly related to TFP (β_1=-.050, p<.001, β_2=.008, p<.001).

Similarly, hypothesis two (H4.2.) proposes a U-shaped relationship between international external knowledge creation and MNE performance. The values and significance of coefficients of international external knowledge and the squared value presented in column 4, Table 4.3. (β_3 =-.028, p<.001, β_4 =.007, p<.001) confirm the hypothesis and show that international external knowledge creation after a certain point exhibits a positive effect on performance.

Given the endogeneity problems mentioned in section six, we estimated all models using system GMM and the xtabond2 command in STATA (Roodman, 2009). The model presented in column one used to specify the productivity estimates as residuals includes also the lagged value of the dependent variable predictor, following system GMM literature (Roodman, 2009). The values of total assets and number of employees are considered as not strictly exogenous following prior literature on obtaining the productivity estimate (Javorcik, 2004; Temouri et al., 2008), and therefore instrumental variables in form of lagged values of respective independents were used. Following the discussion on obtainining the most efficient productivity estimate in section 5.1.1., the dependent variable was also considered as not strictly exogenous and lagged values were used as instruments. The control variables in other models (product diversity, number of operating countries, age, size of the firm, time and industry dummies) were considered as strictly exogenous and instrumenting themselves (Roodman, 2009). Their exogeneity is confirmed by the values of the Hansen tests of exogeneity of instrument subsets (Roodman, 2009). Model 2 in column 4 is the full model where knowledge related variables were considered as not strictly exogenous and therefore,

to account for possible endogeneity, instruments in form of lagged variables were used. All models do not show autocorrelation concerns as in all models autocorrelation is not present (AR2 value is insignificant) and based on the results of the Hansen tests for instrument subsets, the instruments are adequate (Roodman, 2009). Wald tests were used to validate the introduction of the explanatory variables in the model, which substantiated the inclusion of all variables in the model (expression 4.5.). The results of the Wald test for the full model are presented in Appendix 5.

To give a better demonstration of the curvilinear effects, the relationship between the main independents and dependent variable are graphed in Figures 4.1. and 4.2. below. The figures show that the TFP performance of firms decreases when they engage in international internal and external knowledge creation activities at relatively low and moderate levels. Furthermore, the figures indicate that after a certain point, at higher levels of these knowledge creation strategies, MNEs are able to materialise from their advantages and achieve higher performance.

7.1. Robustness checks

To confirm the reliability of results, we employ a series of robustness checks. Firstly we run the models on other measures of MNE performance and compare the results. We estimate MNE performance by using turnover or total sales as the dependent variable (Table 4.4.). Turnover is widely used in prior studies as indicator of performance (Laursen and Salter, 2006). As shown in column 2 Table 4.4. below, the coefficients of all four main independents largely follow the main results. Furthermore, we use labour productivity as an alternative efficiency measure and operating profit as a financial measure of firm success, both used in prior studies (Blomström and Persson, 1983). We estimate labour productivity as total sales per employee (Blomström and Persson, 1983). When the model and method is applied to labour productivity, the results are consistent with the results obtained using TFP and have the same signs and significance (column 4, Table 4.4.). In case of operational profit, the coefficients and significance follow the main results in case of international internal knowledge creation, wheras in case of international external knowledge creation the coefficients showed low significance (column 6, Table 4.4.). However, it can be concluded that the results are fairly robust to other measures of firm performance.

Although argued as biased, we apply OLS and random effects panel regression (following the results of the Hausman test on the baseline model) to specify the models as additional robustness checks. The results are presented in Appendix 6. As expected and emphasised in the literature, the coefficients in OLS may be upward biased, whereas the coefficients in random effects models are severely downward biased (Pindado and Requejo, 2012). The results analyses largely confirm this (Appendix 6). Although the methods yield biased results,

they are still useful as a robustness check and a test of the value of coefficients given by system GMM. The literature suggests that a good check for the value of parameters is to compare the three groups of estimates: OLS, RE and system GMM (Roodman, 2009). If the parameters given by system GMM are true, they should lie in the range between the OLS and RE values (Roodman, 2009). Additionally, estimates should be below 1.00 since values above 1.00 imply an unstable dynamic (Roodman, 2009). The system GMM estimates satisfy these conditions.

Table 4.1. indicated that high-technology firms account for a dominant share of all international patents. Therefore, since high-technology MNEs engage more in international knowledge creation, the performance effect of international internal and external knowledge creation may differ for the two industry groupings. As a robustness check we split the sample in these two groups and run the models again. The results, presented in Appendix 7, show differences when testing the hypotheses on the two industry groupings, which confirms that type of industry matters for the relationship between international internal and external knowledge creation and performance. In case of lower technology industries, the results follow the main results for the whole manufacturing industry, whereas in case of higher technology industries, international internal patents show a reverse U-shaped relationship with TFP, which differs from the main results. Therefore, the average manufacturing industry effect of international internal and external knowledge creation on performance may differ depending on the industry grouping.

Table 4.3. The effect of international internal and external knowledge on TFP

	Hypothesis	Production function	Baseline model	Model 1	Model 2
Dependent variable:		Turnover	TFP	TFP	TFP
		(1)	(2)	(3)	(4)
Independents					
Lagged dependent variable		.688***	.907***	.918***	.923***
		(.018)	(.004)	(.003)	(.005)
Total assets		-.004*			
		(.001)			
Number of employees		.179***			
		(.024)			
International patents, internal	H4.1.			**-.003****	**-.050*****
				(.001)	**(.006)**
International patents, internal²	H4.1.				**.008*****
					(.001)
International patents, external	H4.2.			**-.005*****	**-.028*****
				(.001)	**(.005)**
International patents, external²	H4.2.				**.007*****
					(.001)
Controls					
Single country patents			-.014***	-.008***	-.008***
			(.002)	(.001)	(.001)
Product diversity			.028***	.012***	.014***

		(.005)	(.003)	(.003)
Number of countries		-.005	.001	.004
in which MNE operates		(.003)	(.003)	(.003)
Intangible Assets		.002**	.007***	.006***
		(.001)	(.001)	(.001)
Age		-.023***	-.019***	-.018***
		(.005)	(.003)	(.003)
Size (dummy)		.058***	.032***	.031***
		(.008)	(.006)	(.006)
Time (dummy)	Included	Included	Included	Included
Industry (dummy)	Included	Included	Included	Included
(Constant)	2.591***	1.139***	.924***	.351***
	(.248)	(.063)	(.059)	(.060)
AR(2) z-value	0.01	-1.15	-0.80	-0.91
Sargan test	431.50	276.59	282.93	288.46
Hansen test	53.33	113.44	132.22	129.20
Number of instruments	68	111	143	145
F value	334.14	789.42	709.31	755.90
Number of observations	1350	1350	1350	1350
Estimation method	System GMM	System GMM	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors are in parentheses. Lagged dependent variable, Total assets, Number of employees, Intangible assets and knowledge based indicators were considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets and following similar studies (Uotila et al., 2009). Model 2 is the full model (expression 4.5.), whereas Model 1 excludes the squared values of the two main independent variables.

Table 4.4. The effect of international internal and external knowledge on turnover (sales), labour productivity and operating profit as indicators of performance

	Hypothesis	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Dependent variable:		Turnover	Turnover	Labour productivity	Labour productivity	Operating Profit	Operating Profit
		(1)	(2)	(3)	(4)	(5)	(6)
Independents							
Lagged dependent variable		.791***	.791***	.770***	.648***	.434***	.431***
		(.008)	(.008)	(.021)	(.020)	(.005)	(.005)
Total assets/ Total assets per employee		-.005***	-.005***	-.001	.012†	.105***	.036***
		(.001)	(.001)	(.005)	(.007)	(.004)	(.007)
Number of employees		.121***	.126***			.489***	.372**
		(.013)	(.014)			(.078)	(.127)
International patents, internal	H4.1.	**-.026*** **	**-.020** **	**-.039*** **	**-.183*** **	**-.640***	**-.420***
		(.006)	**(.006)**	**(.011)**	**(.043)**	**(.033)**	**(.055)**
International patents, internal²	H4.1.		**.015***		**.029*** **		**.490** **
			(.006)		**(.008)**		**(.042)**
International patents, external	H4.2.	**-.006*** **	**-.007*** **	**-.011** **	**-.171*** **	-.122	-.231
		(.001)	**(.002)**	**(.004)**	**(.023)**	(.010)	(.013)
International patents, external²	H4.2.		**.018*** **		**.040*** **		.052
			(.006)		**(.005)**		(.016)
Controls							
Single country patents		-.031***	-.029***	-.026†	-.001	-.036	-.050

	(.006)	(.006)	(.013)	(.007)	(.030)	(.034)
Product diversity	-.061***	-.064***	-.122***	-.192***	-.065	-.113
	(.016)	(.016)	(.033)	(.043)	(.012)	(.125)
Number of countries	-.066***	-.061***	-.155***	-.144***	-.085	-.142*
in which MNE operates	(.008)	(.008)	(.003)	(.030)	(.061)	(.084)
Intangible Assets	.008***	.008***	-.015***	-.016***	-.074***	-.006
	(.001)	(.001)	(.027)	(.004)	(.007)	(.010)
Age	-.013	-.012	-.065*	-.058	.227***	.265***
	(.011)	(.010)	(.027)	(.036)	(.074)	(.076)
Size (dummy)	.250***	.247***	.306***	.370***	.239**	.099
	(.012)	(.012)	(.037)	(.056)	(.088)	(.136)
Time (dummy)	Included	Included	Included	Included	Included	Included
Industry (dummy)	Included	Included	Included	Included	Included	Included
(Constant)	1.780***	.654*	1.656***	.145	-3.581***	-.350
	(.011)	(.120)	(.243)	(.363)	(.613)	(.971)
AR(2) z-value	0.35	0.35	0.81	0.78	0.93	0.93
Sargan test	591.38	581.01	105.79	237.54	169.97	208.26
Hansen test	114.33	114.31	79.05	60.08	136.76	130.98
Number of instruments	113	115	90	155	167	222
F value	111.36	118.76	62.22	32.95	20.21	23.89
Number of observations	1350	1350	1350	1350	1350	1350
Estimation method	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors are in parentheses. Lagged dependent variable, Total assets/Total assets per employee, Number of employees, Intangible assets and knowledge based indicators were considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets. Model 2 is the full model (expression 4.5.), whereas Model 1 excludes the squared values of the two main independent variables.

Figure 4.1. The curvilinear effect of International internal knowledge on MNE Total factor productivity

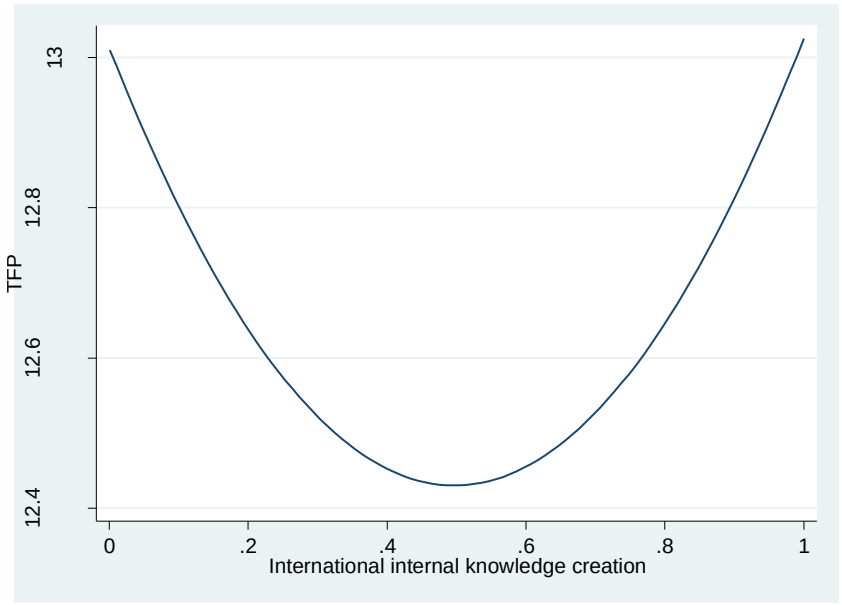
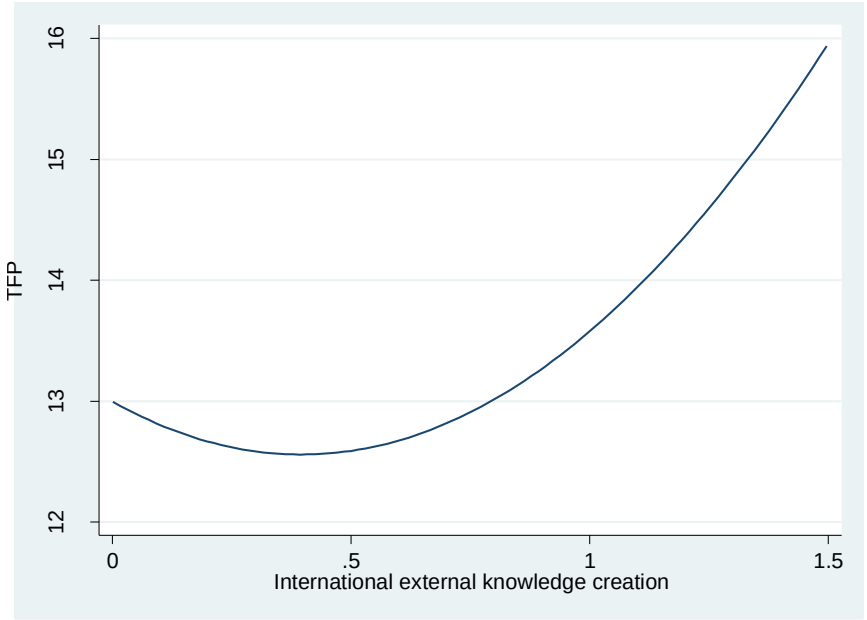


Figure 4.2. The curvilinear effect of International external knowledge on MNE Total factor productivity



8. DISCUSSION AND CONCLUSION

Despite growing interest in the literature regarding the importance of international knowledge creation for the MNE (Alcácer and Zhao, 2012; Berry, 2014; Florida, 1997; Kogut and Zander, 1992; Kogut and Zander, 1993; Patel et al., 2014; Van de Vrande, 2013; Yang et al., 2008), many of its aspects still remain largely unexplored (Foss and Pedersen, 2004; Kotabe et al., 2007; Phene and Almeida, 2008). For instance, research has not yet fully accounted for the possibility that different international knowledge creation strategies may have specific values for the MNE.

Furthermore, the existing evidence offers contradictory arguments about the value of international knowledge creation. On one hand, international knowledge is viewed as a strategy to access heterogeneous knowledge that the MNE would not have access to otherwise, which improves the knowledge base of the MNE and its capability to create new knowledge, which in turn drives performance (Birkinshaw and Hood, 1998; Chung and Yeaple, 2008; Kogut and Zander, 1992; Kogut and Zander, 1993; Phene and Almeida, 2008). On the other hand, studies argue that international knowledge may be the costliest and riskiest knowledge creation strategy due to high governance costs, potential negative spillover effects and the possibility that the new ideas available through the strategy will have limited value because they do not complement the existing knowledge base (Kogut and Zander, 1992; Kogut and Zander, 1993; Leiponen and Helfat, 2010; March, 1991).

8.1. Theoretical and practical implications

This chapter contributes to the discussion regarding the different strategies MNEs use in order to create international knowledge and their value for the whole MNE. By analysing the potential benefits MNEs may gain by engaging in internal and external international knowledge creation, we show when and how these strategies can lead to higher performance. We argue that both internal and external international knowledge creation can reinforce the MNE's existing knowledge base and knowledge creation capabilities, but at the same time represent the most complex knowledge creation strategies accompanied by particular challenges. By doing this, we extend prior studies that considered the different ways in which subsidiaries and MNEs create knowledge, but did not explicitly analyse the performance consequences depending on the strategies used to create knowledge.

Specifically, we show that MNEs need to surpass a certain threshold point of engaging in internal and external international knowledge creation for the positive performance effects to materialise. Governance costs, higher resources needed to codify the diverse knowledge

accessed through these strategies and efforts to select the most valuable ideas make it difficult for firms to benefit from internal and external international knowledge creation. However, as they engage in these strategies more, the costs are reduced and MNEs can advance their performance based on the higher diversity of knowledge and stronger capabilities as a consequence of these strategies.

The results from the analyses show that both internal and external international knowledge creation have a U-shaped relationship with MNE performance. These effects suggest that international knowledge creation has a significantly different effect on performance than when international knowledge is used as a source or flow in the firm's knowledge creation process. Prior studies showed that firms do not benefit from high levels of international knowledge content when developing innovations (Kotabe et al., 2007; Laursen and Salter, 2006) or from extensively acquiring or outsourcing their R&D activities (Berchicci, 2013; Grimpe and Kaiser, 2010). This shows that the value of different international knowledge creation strategies is very specific compared to other forms of integrating international knowledge into the firm. Furthermore, the results suggest that internal and external international knowledge creation may be the most suitable form of integrating and benefiting from high levels of heterogeneous international knowledge in the MNE.

This chapter also emphasises the importance of international collaborative relationships in particular when creating knowledge. In this way, we add to recent studies which postulate that formal collaborative knowledge creation relationships specifically can provide the firm with diverse information and capabilities needed in order to create valuable knowledge in the future (Alnuaimi et al., 2012; Frost and Zhou, 2005; Lahiri, 2010). Moreover, the evidence provided add to prior studies which posit that MNEs cannot access valuable knowledge just by operating in different countries and in fact show that they need to use their multiple country locations as a foundation for building collaborative relationships that enable international knowledge creation (Alnuaimi et al., 2012; Berry, 2014; Singh, 2008).

Prior studies suggest that firms should create knowledge using more open models of knowledge creation which may include different internal and external collaborators (Chesbrough and Crowther, 2006; Laursen and Salter, 2006). We show that although this paradigm is valuable, the performance effects of more open models of knowledge creation in form of internal and external international knowledge creation strategies specifically show that this holds only for firms which engage extensively in these strategies.

The analysis highlights the increased importance of internal and external international knowledge creation as strategies which the MNEs may use to create knowledge. The data

collected confirms the trend noted by recent studies which is that the share of international knowledge has grown from one fifth to one third of all patents (Berry, 2014). Therefore, more and more MNEs are choosing internal and external international strategies to create knowledge, which makes research into this phenomenon highly relevant.

Most importantly, the evidence presented suggests that managers should be cautious when expecting a positive return on internal and external international knowledge creation when the levels of such strategies are low. Internal and external international knowledge creation are ambitious strategies which bring challenges and costs and may put the existing knowledge base at risk. Implementing such complex strategies may make the firm lose focus in the overall knowledge creation strategy. However, after a certain threshold of these strategies is surpassed, firms can materialise on the advantages that these knowledge creation strategies bring. In other words, the results suggest that managers may need a certain level of experience in engaging in these strategies in order to benefit from them. And, it may be the case that, by engaging extensively in international knowledge creation the managers may recognise which of these international collaborations are most valuable and pursue them more vigorously in order to create new valuable knowledge.

9. LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH

This chapter has limitations both on conceptual and methodological level. On conceptual level, we do not consider other possible origins of knowledge creation. For instance, there is a plethora of studies indicating the importance of the type of technology firms use and develop while creating new knowledge, whether it is exploratory or exploitative (Ahuja and Katila, 2001; Benner and Tushman, 2003; Hoang and Rothaermel, 2010; March, 1991). Combining our results with a consideration of the technological origins of knowledge creation would provide the opportunity for performance effects of different international knowledge creation strategies to be scrutinised further. For instance, we could analyse whether the type of technology firms create by engaging in international internal or external knowledge creation conditions the effect of these strategies on performance. Future studies should examine these relationships in order to uncover the true value of different international knowledge creation strategies on MNE performance.

Furthermore, we do not consider different MNE, unit, partner and country specific effects which may impact the key relationships (Hansen and Wernerfelt, 1989). For instance, prior studies showed that knowledge creation benefits may depend on the organisational design and structure of the MNE such as centralisation or decentralisation of innovative activity (Argyres and Silverman, 2004; Berry, 2014; Foss et al., 2013; Jansen et al., 2006). Even though we

capture the knowledge creation strategy of each first level MNE unit, we do not consider whether the knowledge is created by the same units or whether different units participate in these relationships.

Moreover, we do not capture whether international knowledge creation is more beneficial if more than two units participate in the process. Also, other features of the collaborative relationships such as the type, closeness or strength of a relationship between partners might be related to the effectiveness of international knowledge creation (Argote et al., 2003; Berry, 2014). The unit's position in the MNE may also define the existence and value of knowledge creation collaborations. Units which have a more central network position may have a greater tendency to engage in international knowledge creation and derive more value from it (Tsai, 2001). Combining our results with insights from network theory would enable us to uncover whether the value of different international knowledge strategies might depend on the extensiveness of social interaction between units or their network position (Ghoshal and Bartlett, 1990; Tsai, 2001).

Also, the benefits of particular knowledge creation strategies may depend on specifics of the partners and units involved. Many studies suggest that the effects on performance depend upon partner type: competitors, suppliers, customers, universities and research institutes (Belderbos et al., 2004) or their level of know-how and similarity of information (Dushnitsky and Shaver, 2009; Hoang and Rothaermel, 2005). Not all partners will provide the firm with the same level and diversity of new knowledge and therefore, international knowledge creation involving particular partners may have specific value for the MNE. In fact, collaborating with external partners from more similar industries or that are more familiar enhances performance (De Clercq and Dimov, 2008). Also, the value of international knowledge may differ depending on the features of units that engage in these processes, units with stronger learning capacity may be more motivated to engage in the activities and the outcome may be of higher value (Cohen and Levinthal, 1990; Tsai, 2001).

Prior studies argue that the value that can be obtained from knowledge depends also on the characteristics of the country environment (Venkatraman and Prescott, 1990). Since knowledge varies across countries which differ according to the ability to produce and commercialize a flow of innovative technology (Furman et al., 2002), the potential benefits of international knowledge creation may depend on the countries that the co-creators operate in. It would be interesting to analyse whether international knowledge creation strategies differ depending on the origin of the collaborators.

A crucial assumption that this study is based on is that all patents that represent knowledge creation are of same value. However, some may represent radical innovations, whereas others

may be incremental advances without significant implications for the technological field (Griliches, 1998b). In this way, the performance value may also be determined by the value of the international knowledge creation project (patent) itself. Particular international internal and external knowledge creation projects may differ according to their specific value which may also determine their performance effect. Although this would be possible to analyse by looking at the citations each of the patents in the sample gained, due to the time limitations this was not feasible.

In addition to the value issue of each patent, we also limit our study to patents as forms of knowledge creation in the firm. However, as discussed in section 4.2.2. of this chapter, patents do not capture all possible forms of knowledge creation and future studies should examine whether the same effects hold when other forms are considered.

Finally, the conclusions are limited by the sample and time period of focus. Further studies may wish to test the assumptions using a sample of MNEs headquartered in different countries and a combined sample of MNEs from different countries or country groupings and compare the effects. For instance, it may be the case that emerging market MNEs may benefit from international internal and external knowledge creation strategies differently.

CHAPTER V

COMBINING KNOWLEDGE CREATION OF DIFFERENT ORIGIN IN A BALANCED WAY AND MNE PERFORMANCE

1. INTRODUCTION

MNEs can create knowledge using different strategies ranging from individual unit, single country strategies to international knowledge creation involving various internal and external partners such as other units, universities, research centres which may operate in different countries (third chapter, Figure 3.1.) (Kogut and Zander, 1992; Kogut and Zander, 1993). In fact, many MNEs, through their global network of subsidiaries, are increasingly creating knowledge in multiple countries using international internal or external strategies (Ahuja and Katila, 2004; Berry, 2014; Feinberg and Gupta, 2004; Florida, 1997; Kotabe et al., 2007; Leiponen and Helfat, 2010; Patel et al., 2014; Phene and Almeida, 2008; Van de Vrande, 2013).

Since MNEs may create knowledge using different strategies, they face the challenge of how to allocate scarce inputs between these strategies to maximise returns and reconcile their knowledge creation aims. Knowledge created using individual unit single country strategy offers higher protection and control, but in order to survive in the global economy firms need to open their knowledge creation boundaries and collaborate to stay competitive. This contributes to a degree of conflict in the firm's knowledge creation strategy. The question which knowledge creation strategy or which combinations of strategies to focus on becomes significant. In fact, combining different knowledge creation strategies within the same MNE with the aim of capturing specific advantages that each strategy provides represents a crucial knowledge creation challenge.

MNEs need to make choices regarding the internal allocation of resources towards international knowledge creation as opposed to single country knowledge creation and whether to focus on individual, internal or external knowledge creation strategies (Birkinshaw and Hood, 1998). MNEs need to choose which subsidiaries will engage in different knowledge creation strategies and how, whether they will create knowledge individually or with partners or both (Birkinshaw and Hood, 1998). However, little has been said as to how MNEs combine knowledge creation strategies of different locational and organisational origins, whether they balance or prioritise between them, and how these choices impact performance. What we do not know is whether and in which ways it is beneficial for the MNE to combine knowledge

creation of different locational and organisational origins simultaneously in their knowledge creating portfolio.

To address this tension, we analyse how MNEs combine different knowledge creation strategies and examine the value of these combinations. Firstly, this approach aims to offer a better understanding of how MNEs can build their performance by engaging in different combinations of knowledge creation strategies. Secondly, by analysing the combinations of MNE knowledge creation strategies on both locational and organisational origins simultaneously rather than separately, we are able to offer a more complete account of the different combinations of strategies that MNEs use to create knowledge. Finally, by capturing knowledge creation projects within the whole MNE and relating it to their locational and organisational choices for knowledge creation, this study differs from previous studies which examined the value of combining knowledge creation of different origin on unit or individual project level.

In order to develop the hypotheses, we primarily draw from the knowledge of the firm theory supported by interrelated theories. By testing the value of a balanced combination between single country and international and different strategies of international knowledge creation in the overall MNE knowledge creation strategy we offer conclusions regarding whether pursuing different combinations of knowledge creation strategies at the same time is beneficial. To test the hypotheses, a dataset of 46,712 knowledge creation projects by 150 UK headquartered firms and their 5,352 first level subsidiaries operating in more than 112 different countries from 2003 to 2012 was used. We find that simultaneously balancing both single country and international knowledge creation rather than prioritising builds group level performance. Also, a balanced combination of both internal and external international knowledge creation is more beneficial.

2. THEORY AND HYPOTHESES

MNEs simultaneously combine different knowledge creation strategies for the same purpose which is to bring together diverse knowledge that can be transferred and recombined into new knowledge throughout the group (Kogut and Zander, 1993). In this view, firms expect to capitalise on diversity of information they have access to through a combination of the different ways in which they create knowledge (Kogut and Zander, 1993).

In the previous chapter we analysed the value of particular knowledge creation strategies in the MNE with the assumption that MNEs combine them in similar ways within their overall knowledge creation strategy. However, different MNEs may opt for different combinations of knowledge creation strategies which may account for differences in performance. For instance,

Vodafone and GlaxoSmithKline combine knowledge creation strategies in very different ways. Vodafone creates majority of its patents individually using single country strategies, while many of GlaxoSmithKline's patents are created using international, multi-country strategies with many units participating in the knowledge creation processes (third chapter, Figures 3.5. and 3.7.).

Studies suggest that the MNE is not able to gain necessary advantages from just one type of knowledge as different knowledge strategies result with different benefits. For instance, internal knowledge is positively associated with patent output, while external knowledge such as R&D collaborations are associated with a stronger reputation for holding superior abilities in the technological domain (Nicholls - Nixon and Woo, 2003), hence a strategy that would capture both is desired. Also, different knowledge strategies have an effect on different aspects of firm capabilities. External knowledge in particular affects the firm's capability to create new products, whereas internal knowledge affects the firm's capability to create both new products and processes (He and Wong, 2004). However, firms are limited by their internal resources and therefore need to make choices regarding the most efficient way in which to allocate them (Birkinshaw and Hood, 1998).

2.1. Combining single country and international knowledge creation in a balanced way and MNE performance

According to the locational origins of knowledge creation, firms can choose to create knowledge by either using single country or international strategies, or they can choose to combine both which they can do in two different ways. MNEs can combine single country and international knowledge creation by prioritising between them in which case one strategy dominates, or by applying both in a rather balanced way with a fairly equal and simultaneous emphasis on each of the two strategies.

Knowledge of the firm suggests that combining both single country and international knowledge creation in a more balanced way is expected to have a positive effect on MNE performance based on two mechanisms: by reducing the risk of focusing on a limited set of technological opportunities and by minimising the risk of imitation (Kogut and Zander, 1992; Kogut and Zander, 1993). MNEs, in order to grow, need access to valuable knowledge creation opportunities, but at the same time need to protect themselves from imitation (Kogut and Zander, 1992). Because of these mechanisms, MNEs which combine both single country and international knowledge creation in a balanced way in their overall knowledge creation strategy will be in a better position to achieve their knowledge creation and performance aims compared to MNEs which combine the two in an unbalanced way or focus on just one strategy.

Single country knowledge creation, individual in particular, is a strategy widely used in core knowledge creation projects in which the risk of valuable knowledge being imitated by competitors is high (Belderbos et al., 2013; Di Minin and Bianchi, 2011). Engaging in single country knowledge creation enables the MNE to protect its valuable knowledge. In fact, the tension to deploy more resources to single country knowledge as opposed to international is based on the need to centralise the knowledge management of crucial MNE knowledge base and core knowledge creation projects (Belderbos et al., 2013; Di Minin and Bianchi, 2011; Kogut and Zander, 1992).

However, its main limitation is the dependence on homogeneous, within group behaviour of individuals with similar backgrounds who recycle only already available knowledge, which may lead to redundant ideas and processes and therefore may not bring new knowledge opportunities (Berry, 2014; Burt, 2004; Kogut and Zander, 1992). In this view, firms which assign all or the majority of their resources to single country knowledge creation will as a result have a disadvantageous knowledge base which will limit their potential for future knowledge creation and therefore have a negative effect on MNE performance (Kogut and Zander, 1992; March, 1991). Focusing the majority of knowledge creation efforts on single country knowledge creation will result with a very limited set of established knowledge creation processes which will ultimately make the firm uncompetitive in the changing technological landscape.

International knowledge creation, in contrast to single country knowledge creation, by providing the MNE with access to heterogeneous knowledge in many cases from more than two different countries, is the main source of new knowledge opportunities which enable the firm to create valuable knowledge in the future (Kogut and Zander, 1992). Therefore, the pressure to distribute a higher share of resources to different international knowledge creation strategies is based on the need to develop a wider, richer and more diverse knowledge base on MNE level by accessing divergent knowledge from internal and external sources operating in different country locations (Kogut and Zander, 1992; Patel et al., 2014).

As discussed in the previous chapter, a diverse MNE knowledge base is necessary in order to create tailored new innovations for specific distant markets. It enables the firm to position the product faster into international markets than the competition, while an emphasis on single country knowledge creation may limit the number of markets that the firm is able to successfully serve and slow down the internationalisation process, all of which will negatively affect performance (He and Wong, 2004; Patel et al., 2014). In this way, the MNE can potentially gain a larger share of the global market compared to firms which keep their knowledge creation operations focused, narrow and location specific.

However, assigning all or the majority of MNE resources to international knowledge may result with too many knowledge opportunities and ideas which the firm cannot pursue effectively and with the inability to protect the most valuable ones from imitation (Kogut and Zander, 1992). Since international knowledge creation is more complex as it brings together diverse cross-country knowledge, in order for it to be transferred and recombined within the MNE it also needs to be codified, which makes it more vulnerable to imitation (Kogut and Zander, 1992). Because of the risk of imitation, the firm may choose to create the most valuable knowledge using individual, single country strategies.

Therefore, pursuing both single country and international knowledge creation simultaneously in a balanced way hedges the risk of focusing on a limited set of technological opportunities and the risk of imitation, which enables the MNE to achieve their knowledge creation and performance goals more effectively. MNEs which employ a balance of the two are better able to benefit from advantages of both by choosing a safe context to create core knowledge in, while simultaneously having access to a variety of information.

According to the literature, MNEs can combine single country and international knowledge creation in a balanced way by using two different approaches. First, they can pursue both strategies simultaneously as matching, or secondly, they can switch through periods of single country and international knowledge creation, where they have a strong focus on one strategy at one moment in time and a strong focus on the other at a different time (Boumgarden et al., 2012; Gupta et al., 2006; Mudambi and Swift, 2011).

We define and measure balance between single country and international knowledge creation by testing for the first approach. Following prior literature, we test whether a match or, specifically, a smaller absolute difference between single country and international knowledge creation benefits MNE performance (He and Wong, 2004). We expect this approach to be superior to the alternative which suggests, as mentioned, the application of different strategies at different times for two reasons: the specialisation trap and self-reinforcement. The literature showed that creating different knowledge strategies at different times will create a specialisation trap for the subsidiaries involved and the subsidiaries will not be successful at developing a strategy which is different and requires different know-how, whereas a simultaneous matching of both will enable a constant inflow of new ideas and processes, enabling the MNE to combine different approaches and benefit from this diversity (March, 1991). Furthermore, the strategy of switching distorts internal competition for resources due to self-reinforcement (Birkinshaw and Hood, 1998; March, 1991). A stronger focus on one knowledge creation strategy leads to short term success, which then reinforces further specialisation and therefore, a need to devote even more resources to that one strategy which distorts competition and may ultimately result in employing just one knowledge creation

strategy, which initially proved as successful, for a longer period of time bringing in limitations that accompany the use of only single country or international knowledge creation exclusively (Gupta et al., 2006; March, 1991).

Therefore, we expect that firms which combine and match both single country and international knowledge creation simultaneously in a more balanced way will benefit more than firms focusing on just one strategy. In this view, a rather equal combination of single country and international knowledge creation will minimise the limited knowledge opportunities and imitation risks and therefore provide the MNE with the most effective environment for knowledge creation, which will have a positive performance effect. We suggest that the optimal strategy for the MNE would be to have a balance between single country and international knowledge creation in the overall knowledge creation strategy. The hypothesis is:

Hypothesis 1: The positive effects of knowledge creation on MNE group performance will be stronger for MNEs that combine single country and international knowledge creation in a more balanced way than for MNEs that combine single country and international knowledge creation in an unbalanced way. (H5.1.)

2.2. Combining international internal and external knowledge creation in a balanced way and MNE performance

Since international knowledge creation can be either internal or external, the issue of how to combine both within the international part of the overall knowledge creation strategy is important. International internal and external knowledge creation refers to multi-country knowledge created either internally in cooperation with other subsidiaries (within the MNE network) (third chapter, cell 3, Figure 3.1.) or with external partners outside the MNE (third chapter, cell 4, Figure 3.1.). MNEs may choose to focus exclusively either on internal or external international knowledge creation or opt for a combination of the two, in which case they can either allocate their resources and efforts simultaneously on both by adopting a balanced approach or use both strategies with one dominating.

Knowledge of the firm suggests that what is important in building significant variations in performance is the efficiency with which MNEs create knowledge (Kogut and Zander, 1992). Specifically, efficiency in knowledge creation depends on the speed at which the MNE can transfer and recombine knowledge compared to others (Kogut and Zander, 1992). A balanced combination of international internal and external knowledge creation may particularly contribute to MNE knowledge creation efficiency by ensuring that new external knowledge accessed will be transferred quickly throughout the MNE. In this view, MNEs that combine

international internal and external knowledge creation in a balanced way in their overall knowledge creation strategy will achieve higher knowledge creation efficiency compared to MNEs which combine the two in an unbalanced way or focus on just one strategy based on one main mechanism: by ensuring that the newly accessed knowledge is transferred and exploited successfully in the MNE.

The main advantage of international external knowledge creation is that it enables a high inflow of new ideas into the firm, but this knowledge creation strategy suffers from difficulties related to differentiating which projects specifically would be valuable to pursue. Therefore, MNEs may suffer from the risk of having too many ideas with limited value for the firm (Belderbos et al., 2010; Faems et al., 2010; Laursen and Salter, 2006; Nicholls - Nixon and Woo, 2003). This eventually results in a knowledge portfolio that is extensive but not efficient, where there are many unfinished new ideas and projects with limited direct value and potential because the firm does not have the capability to pursue all possibilities and benefit from them (March, 1991). However, MNEs that combine external international knowledge creation with internal may be more successful in minimising and avoiding these risks by utilising the potential of the new knowledge better.

One of the main advantages of international internal knowledge creation, compared to international external, is that the subsidiaries involved are already familiar with the MNE's knowledge creation system, which makes new knowledge based on this strategy easier to create. Since MNEs are organisations that transfer institutional infrastructure, rules, incentives and enforcement mechanisms across borders (Dunning and Lundan, 2010; Szulanski, 1996), there are knowledge creation mechanisms set up within the MNE which enable a speedy process of knowledge creation if the collaborators belong to the same MNE. This contributes to shorter lead time, higher efficiency, less risk and lower governance costs. Based on this advantage, international internal knowledge can be conceptualised as a mechanism for transferring new knowledge accessed through external international knowledge creation across the group, which will build the MNE's knowledge creation efficiency and benefit performance (Kogut and Zander, 1992).

Focusing on just one type of international knowledge creation may not be beneficial for MNE knowledge creation efficiency. For instance, relying only on internal international knowledge creation may lead to path dependent decisions and ideas which are not novel enough to compete because they are based on internal MNE processes which are familiar. Since in international internal knowledge creation the partners belong to the same MNE, they have certain similarities and the more they create knowledge in collaboration the more similar their knowledge base becomes, which then limits access to new knowledge for the MNE.

Combining internal and external international knowledge simultaneously will potentially mitigate these limitations.

Since external international knowledge creation provides access to diverse knowledge, sharing and recycling it using internal international knowledge creation will generate significant performance benefits (Kogut and Zander, 1992; Kogut and Zander, 1993). This balancing strategy enables the firm to maximise on knowledge systems already present in the MNE by enabling the opportunity to make novel linkages with new external international knowledge flowing into the firm (Nicholls - Nixon and Woo, 2003). In this view, the firm could fully integrate the benefits of an inflow of new knowledge based on these strategies across the MNE with a greater probability that the new knowledge will be transferred, replicated and transformed in high value innovations, which will have a positive effect on performance (Kogut and Zander, 1992). By combining both strategies simultaneously in a balanced way, the firm could leverage and utilise the benefits based on a global presence and an extensive network of collaborating subsidiaries more effectively.

Similar to previous hypothesis, we expect that MNEs which simultaneously employ both strategies will benefit more that firms focusing on just one strategy or each strategy at a time, therefore avoiding the risk of specialisation and self-reinforcement discussed in the previous section. We expect that a simultaneous balance of both international internal and external knowledge creation will build the knowledge creation efficiency of the whole MNE and therefore its performance by enabling a constant inflow of new knowledge and ideas and by more successfully selecting, transferring and exploiting them into high value innovations through international internal knowledge creation. There will be higher prospects that the ideas will be developed further into new knowledge by more units, and therefore the diversity of know-how will be fully utilised. Also, more of different new knowledge available across the firm suggests that MNEs can benefit from a wider field of innovating and have a higher likelihood of expansion in a related and even unrelated technological domain, which will positively affect performance. In this view, the limitation of having too many ideas as an outcome of international external knowledge creation will be outweighed by the greater absorption of new ideas on the MNE level using international internal knowledge creation. The hypothesis is:

Hypothesis 2: The positive effects of knowledge creation on MNE group performance will be stronger for MNEs that combine international internal and external knowledge creation in a more balanced way than for MNEs that combine international internal and external knowledge creation in an unbalanced way. (H5.2.)

3. DESCRIPTION OF THE DATA

As discussed in detail in section 4 of the fourth chapter, this research is based on MNE level data to account for private returns to knowledge creation. The sample includes 150 largest manufacturing sector firms headquartered in the UK and the observation period is from 2003 to 2012. The data has a panel structure, the advantages and disadvantages of which are discussed in detail in section 4 of the fourth chapter.

3.3. Data sources and sample

The data sources are presented and discussed in detail in chapter four section four. As mentioned, the selection of firms was made based on two conditions, first according to the company's most recent turnover and second, the sample included firms that engaged in knowledge creation in the period in form of patents granted. Firm level panel data was collected and combined from two sources widely used in previous studies, Bureau Van Dijk Fame database and European Patent Office (EPO) Espacenet database. The table in Appendix 1 provides detailed information about the sources of raw data. The two sources are discussed in detail in section 4 of the fourth chapter. Fame database was used to collect financial data and organisational structure information, as in other recent studies (Arora et al., 2014; Brouthers, 2002; Cui and Jiang, 2012), and the EPO database was used for patent information of both headquarters and subsidiaries for the selected time period, used in previous studies (Grimpe and Hussinger, 2013; Hall et al., 2007; Reitzig and Wagner, 2010; Salomon and Jin, 2010; Wagner et al., 2013). The resulting database for the purpose of this research provided the financial, organisational and knowledge creation information for selected MNEs and its first level subsidiaries for the 2003 to 2012 period. The full sample includes 150 MNEs and 5,352 first level subsidiaries operating in more than 112 countries which recorded in total 46,712 knowledge creation projects in the selected period. The representativeness of the sample is also discussed in section 4 of the fourth chapter.

4. VARIABLES

4.1. Dependent variable

The dependent variable for testing the above mentioned hypotheses is MNE performance measured as *Total factor productivity (TFP)*, widely used in other knowledge and performance studies (Driffield et al., 2010; Javorcik, 2004; Liu et al., 2009). The advantages of this measure in relation to other measures of performance are discussed in detail in section 5 of the fourth chapter. As argued in previous chapter, TFP allows for estimation of the share of productivity growth arising from knowledge creation strategies (Griliches, 1979). Following the operationalization of the dependent variable from previous chapter, TFP is given as the

combined residual of a Cobb-Douglas production function which takes into account knowledge as input, an approach well established in the literature (Adams and Jaffe, 1996; Griliches, 1992; Kafouros et al., 2008; Liu et al., 2009; Scherer, 1982). As mentioned in chapter four section 5, the production function takes into account factor inputs of capital, labour, year and industry dummies which accounted for the years of recession during the time period selected, as determinants of output. The resulting TFP is a parameter which conditions the relationship between capital, labour and output (Sargent and Rodriguez, 2001) and it is obtained using expression (4.1.) defined in section 5 of the fourth chapter. The estimation strategy is set in accordance to standard methodology (Javorcik, 2004; Temouri et al., 2008) and the model is determined using system GMM which solves the unobserved heterogeneity and simultaneity problem in production functions and has shown to be particularly useful for production functions in short panels (Blundell and Bond, 2000; Wooldridge, 2009). The arguments in favour of system GMM as the preferred method for estimating TFP are discussed in detail in section 5 of the fourth chapter.

4.2. Independent variables

The main independent variables are measures which capture the ways in which MNEs combine different knowledge creation strategies. The paragraphs below discuss their operationalization. The proxy used to develop the different combinations measures is patent assignment information, the advantages and disadvantages of which are discussed in detail in previous chapter.

The first hypothesis explores the extent to which it is useful to combine single country knowledge creation and international knowledge creation strategies simultaneously in a balanced way. We use the fit as matching concept to show the effect of simultaneity of the strategies in the MNE on performance (Venkatraman, 1989). As mentioned in prior literature, in cases where fit is a theoretically defined match between two related variables that affect a third variable, this approach is applicable (He and Wong, 2004; Venkatraman, 1989).

For this purpose, we test the *Balance between single country and international knowledge creation,* B_{it} *,* and its effect on performance. The aim of this construct was to capture the ways in which MNEs allocate resources between different knowledge creation strategies (He and Wong, 2004). To achieve this, we needed to capture not only the extent to which a firm engages in a specific knowledge creation strategy, but also how the extent to which it engages in one strategy compares to the extent to which it engages in the other. We consider the two knowledge creation strategies as independent of each other and adopt a two-step approach to

estimate the final measure, similar to prior studies (Gupta et al. 2006; He and Wong 2004; Jansen et al. 2009).

Firstly we estimated the levels of single country and international patents separately (Gibson and Birkinshaw 2004; Jansen et al. 2009). In the second step we use the subtraction method (He and Wong, 2004) to compare the strategies. An alternative approach would be to multiply the two constructs or add them together (Gibson and Birkinshaw 2004; Jansen et al. 2009), but because we are interested in how firms divide resources between the two rather than whether or not they use both strategies, we consider the subtraction method as superior. In the second step, we estimate the absolute difference between the ratios of single country and international knowledge creation in total defined at level of each unit and then consolidated on the MNE level by dividing the unit level ratios by the number of knowledge creating units (which have at least one patent granted) in the MNE, similar to prior studies (He and Wong, 2004).

In firms which combine single country and international knowledge creation in a balanced way the two strategies will have the same positions in the overall knowledge creation strategy, the firm would devote their resources and efforts equally between them and therefore, approximately similar number of patents would be created using both strategies. In other words, the value of the absolute difference (in number of patents) between the two strategies would be close to zero (0.0) and the balance would be the highest value of one (1.0).

An imbalance appears if one of the knowledge creation strategies dominates, evidenced by more patents created using one of the two strategies. The level of imbalance depends on the extent to which the firm creates more knowledge using a particular strategy. For instance, a MNE may combine the strategies in such a way that 90 per cent of all patents granted are international and 10 per cent are single country patents. In this case, the absolute difference between them is rather high (0.8) due to the dominance of international patents. Since the absolute difference figure actually represents imbalance, we reverse the final number to obtain balance, as in prior studies (Bell, 2005). In the example the reversed value would be 0.2, which shows a low balance value and indicates that the two strategies are not combined in a fairly balanced way.

The expression is:

$$B_{it} = \frac{\sum_{it}(abs.\left[\left(\frac{SP_{ut}}{P_{ut}}\right)-\left(\frac{IP_{ut}}{P_{ut}}\right)\right])}{U_i} \quad (5.1.)$$

where B_{it} represents balance, $\frac{SP_{ut}}{P_{ut}}$ is the ratio of single country patents in total unit patents, $\frac{IP_{ut}}{P_{ut}}$ represents the unit level ratio of international patents in total patents, and U_i is the number

of units which recorded knowledge creation activity in the period. As the above expression actually measures the imbalance, we reverse the variable prior to analysis.

The second hypothesis focuses on exploring the performance implications of a balanced combination of international internal and external knowledge creation in the MNE. For purpose of testing this hypothesis, we developed a measure of *Balance between international internal and external knowledge creation,* Bie_{ij} , which is lower if there are more external international patents created than internal and vice versa. It follows the fit as matching conceptualisation (Venkatraman, 1989) referred to in previous paragraph. Using the same approach, we sum the absolute differences between ratios of internal and external international patents for each unit and then divide them by the number of knowledge creating units in the MNE, U_i, to get a consolidated measure of imbalance, which we reverse. A fairly balanced combination between international internal and external patents is evidenced by a fairly equal distribution of patents created using both strategies in total international patents, and the imbalance is higher if there are more internal or external international patents granted. The expression is:

$$Bie_{it} = \frac{\sum_{it}(abs.\left[\left(\frac{IIP_{ut}}{IP_{ut}}\right)-\left(\frac{IEP_{ut}}{IP_{ut}}\right)\right])}{U_i} \quad (5.2.)$$

where Bie_{it} represents balance, $\frac{IIP_{ut}}{IP_{ut}}$ represents the unit level ratio of internal patents in total international patents, $\frac{IEP_{ut}}{IP_{ut}}$is the ratio of external patents in total international patents and U_i is the number of knowledge creating units.

4.3. Control variables

As in the model mentioned in fourth chapter, we introduce other indicators of MNE performance used widely in prior studies. The production function incorporates *Total assets* and *Number of employees*, adjusted for inflation as indicators of turnover which is used to estimate the TFP levels (Temouri et al., 2008), both of which are expected to have a positive and significant effect. Dummies to control for the effects of time and industry are also used in this initial estimation of TFP and in all other models (Temouri et al., 2008), as in prior chapter.

The main model includes *Product diversity* and *Number of countries in which the MNE operates* as indicators of diversification of the segments in which the firm operates and different locations in which it has its units (Tallman and Li, 1996). The operationalization of these variables follows the one explained in fourth chapter. As discussed, the effect expected is mixed and context specific. As in previous chapter, *Intangible Assets* is used to control for other knowledge based resources (Hall, 1993). We also control for *Age* as years of operation

and *Size* expressed as median of sales dummy, where age of the firm is expected to have a mixed impact on performance and size a positive one, following many prior studies (He and Wong, 2004; Lyles and Salk, 1996; Tallman and Li, 1996).

5. MODEL

The estimation method follows a similar procedure as outlined in fourth chapter. The production function was estimated based on equation (4.1.) in chapter four using system GMM, following prior studies (Temouri et al., 2008). System GMM, as argued in previous chapter is the preferred method as it provides a solution for unobservable heterogeneity and endogeneity issues (Pindado and Requejo, 2012), both of which were emphasised in relation to inputs in production functions (Hall and Mairesse, 1995; Javorcik, 2004). Determinants of the TFP estimate were introduced in the second step, following the same methodology as outlined in previous chapter. The model relates variations in MNE level productivity with knowledge related MNE level independents, in this chapter focused on combining different strategies of knowledge creation. The models are different for each hypothesis as including all independent measures would result in applying the international knowledge element in the equation twice. The models are (Javorcik, 2004; Temouri et al., 2008):

$\varepsilon_{it} = \beta_0 + \beta_1 \varepsilon_{it-1} + \beta_2 B_{it} + \beta_3 Pd_i + \beta_4 C_i + \beta_5 IA_{it} + \beta_6 A_{it} + \beta_7 S_{it} + v_{it}$ (5.3.) for hypothesis 5.1.,

$\varepsilon_{it} = \beta_0 + \beta_1 \varepsilon_{it-1} + \beta_2 Bie_{it} + \beta_3 SK_{it} + \beta_4 Pd_i + \beta_5 C_i + \beta_6 IA_{it} + \beta_7 A_{it} + \beta_8 S_{it} + v_{it}$ (5.4.) for hypothesis 5.2.

where ε_{it} is the TFP estimate in both equations, B_{it} refers to the balance between single country and international knowledge creation, Bie_{it} represents balance between international internal and external knowledge creation, SK_{it} is single country knowledge, Pd_i is product diversity, C_i is the number of countries in which the MNE operates, IA_{it} are intangible assets, A_{it} signifies age, S_{it} refers to size and v_{it} is the error term, i refers to firm and t to the time period.

Both models are estimated using system GMM. The advantages of the method are discussed in detail in previous chapter and include avoiding inconsistent estimates potentially given by other methods such as OLS (Pindado and Requejo, 2012). Furthermore, using this method enables the control of individual heterogeneity and therefore fully utilises the potential of panel data (Pindado and Requejo, 2012). Finally, it is superior to other panel data analysis methods such as random effects as it solves the problem of endogeneity, an issue discussed in

detail in previous chapter, and permits using lagged values of variables to control for it (Pindado and Requejo, 2012).

6. SUMMARY STATISTICS

Table 5.1. presents the descriptive statistics and correlations. The mean values and standard deviations of particular variables have been discussed in previous chapter. The means of the main independent variables, balance between single country and international patents and balance between international internal and external patents are .363 and .225 respectively, with standard deviations of .373 and .360. The correlation matrix shows that both balance between single country and international patents and balance between international internal and external patents are positively and significantly related to turnover as expected ($p<.05$). Also, the two independents are positively and significantly related to total assets and product diversity variables, while balance between international internal and external patents is positively and significantly related to the number of countries in which the MNE operates and the level of intangible assets. The correlation matrix for the control variables has been discussed in the fourth chapter.

Table 5.2. aims to show how MNEs in the sample combine different knowledge creation strategies. For this purpose we categorise the two main independent variables, balance between single country and international knowledge creation and balance between international internal and external knowledge creation into three groups: high, medium and low balance. High balance, for instance, shows that firms combine two strategies of knowledge creation in a rather equal, simultaneous and balanced way, evidenced by a variable score of more than 0.8 up to a maximum score of 1 (based on the variable estimation explained in section 4.2.). The sample was categorised according to these three groups and by firm size and sector categories in order to make conclusions regarding which MNEs use which combinations of knowledge creation strategies.

With regards to the variable Balance between single country and international knowledge creation, the majority of patents regardless of firm size and sector was created using imbalanced strategies, in other words, by using just one of the two strategies (47.1 per cent). MNEs in the sample also frequently created knowledge by combining both knowledge creation strategies, but by giving priority to one of the two, which means that these firms used both strategies of knowledge creation, but one type more than the other (34.1 per cent). A balanced combination of two strategies indicates all cases in which MNEs created patents using both single country and international strategies relatively equally in their overall

knowledge creation strategy, which was also frequently the case (18.7 per cent). Therefore, MNEs in the sample combine the two strategies in different ways.

With regards to the variable Balance between single country and international knowledge creation according to firm size (Table 5.2.), small firms engaged in all three groups, but in most cases created knowledge in an imbalanced way, by using either single country or international knowledge creation strategy. Medium sized firms in the sample frequently engaged in low and medium balanced strategies, but less in highly balanced strategies, which shows that most of these firms usually preferred either single country of international knowledge creation strategy. The largest firms also mostly used a low balanced strategy, where only one is applied. However, many of these firms also engaged in balanced strategies.

Out of all sectors, manufacture of computer, electrical equipment and optical products, manufacture of coke, petroleum and chemicals and manufacture of pharmaceutical products were the three sectors that combined single country and international knowledge creation in a balanced way the most. Out of all observations, 11.5 per cent belong to this variable and these sector groups. MNEs in manufacture of textiles and leather products and manufacture of food, beverages and tobacco products sectors engaged in balanced strategies the least.

Many MNEs from all sectors opted for medium balanced strategies which means that they implement both strategies, but allocate the majority of resources to one which dominates the overall knowledge creation strategy. MNEs belonging to manufacture of coke, petroleum and chemicals, manufacture of computer, electrical equipment and optical products and manufacture of machinery, vehicles and equipment recorded most of the observations of this type in the sample (16.2 per cent of total patents). Manufacture of wood and furniture, paper and paper products and manufacture of rubber and plastic products and manufacture of pharmaceutical products used this specific type the least.

Many firms from all sectors used rather imbalanced strategies of combining single country and international knowledge creation, 48.9 per cent. In these cases, firms opted for just one strategy. Out of these, manufacture of food, beverages and tobacco products, manufacture of machinery, vehicles and equipment and other manufacturing firms used imbalanced strategies the most. Their combined share was 28.8 per cent of total patents.

The independent variable groups can also be categorised according to R&D intensities within different industries, where higher technology industries were considered as more research intensive (Grimpe and Sofka, 2009; OECD, 2011). This categorisation is explained in detail in previous chapter. According to this categorisation, there are significant differences in how

higher and lower technology firms combine single country and international knowledge creation strategies (Table 5.2.). Higher technology industries engage significantly more in highly balanced combinations of these two strategies. More patents were also created using medium balanced combinations of strategies by higher technology industries. In contrast, lower technology firms apply imbalanced combinations of these strategies.

The second independent variable, Balance between international internal and external knowledge creation was also categorised in three groups and analysed according to firm size, sector and industry groupings (Table 5.2.). Out of all patents, 70.7 per cent was created using rather imbalanced combinations of different international knowledge creation strategies. Interestingly, more patents in the sample was created using highly balanced rather than medium balanced combinations of international knowledge creation strategies, 16.0 compared to 13.3 per cent of total patents, which is significantly different than in case of single country and international combinations.

According to firm size, small firms in the sample created patents mostly by using imbalanced or medium balanced combinations of different international knowledge creation strategies and did not apply highly balanced combinations. Medium size firms follow a similar pattern, they combined the strategies in a fairly imbalanced way. Only large firms combine the two strategies in a highly balanced way, out of total patents 15.3 per cent was created using these strategies. Even though the largest firms engage in highly balanced strategies, still the majority of patents were created using low balanced combinations of strategies. Interestingly, the largest firms opted for medium balanced combinations of strategies less compared to the other two groups.

With regards to distribution by sectors, manufacture of coke, petroleum and chemicals, manufacture of pharmaceutical products and manufacture of computer, electrical equipment and optical products combined international internal and external knowledge creation strategies in a highly balanced way the most, 10.1 per cent of all patents was created using this strategy by the three sectors. Manufacture of textiles and leather products, manufacture of food, beverages and tobacco products and manufacture of wood and furniture, paper and paper products were sectors which engaged the least in this strategy.

Manufacture of machinery, vehicles and equipment and manufacture of computer, electrical equipment and optical products engaged most of all sectors in strategies involving both international internal and external knowledge creation strategies, but where one strategy dominates (medium balance). Finally, firms from all sectors engaged extensively in imbalanced strategies of international knowledge creation. The highest frequency of imbalanced combinations of patents was observed in manufacture of coke, petroleum and

chemicals, manufacture of machinery, vehicles and equipment and other manufacturing sectors, which jointly accounted for 35.8 per cent of all patents using this combination.

According to the higher and lower technology grouping, higher technology MNEs combined international internal and external knowledge creation strategies in a highly balanced way with 12.1 per cent of total observations belonging to this sector and variable grouping. Higher technology MNEs also engaged more in medium balanced combinations of the two international knowledge creation strategies than the lower technology grouping. However, there is a similarity. Both groupings combined the two strategies in an unbalanced way the most, with a 30 per cent share of total observations for higher and 35.7 per cent lower technology grouping.

Table 5.1. Summary and pairwise correlation statistics (* denotes significance level<.05)

		Mean	Standard deviation	1	2	3	4	5	6	7	8	9	10
1	Turnover	1174993	1952274										
2	Total Assets	758396.5	1597382	.32*									
3	Number of Employees	7564.07	16115.88	.17*	.13*								
4	Balance single country/international patents	.363	.373	.18*	.04	-.04							
5	Balance international internal/external patents	.225	.360	.07*	-.02	-.27*	.32*						
6	Single country patents	.341	.461	-.19*	- .05*	.22*	-.33*	-.22*					
7	Product diversity	9.73	10.99	-.07*	.10*	.50*	-.18*	.31*	.22*				
8	Number of countries in which MNE operates	7.91	11.56	-.14*	-.08*	.43*	-.22*	-.32*	.26*	.44*			
9	Intangible Assets	291577.2	1247902	.30*	.40*	.31*	.32	-.12*	.01	.25*	.01		
10	Age	50.53	33.28	-.01	.02	- .04	-.01	.03	-.04	-.01	-.16*	-.10*	
11	Size (dummy)	.5	.50	.61*	.18*	.19*	.01	.01	-.05*	.09*	.08*	.24*	-.01

Table 5.2. Balance between different strategies of knowledge creation by firm size and sector categories

Percentage of observations (%)	**Balance single country/international patents**			**Balance international internal/external patents**		
	High balance (values>0.8)	Medium balance (both strategies, one dominates, values <0.8 and >0.2)	Low balance (values <0.2)	High balance (values>0.8)	Medium balance (both strategies, one dominates, values <0.8 and >0.2)	Low balance (values <0.2)
Size						
<500 employees	0.1	2.8	4.9	0.0	2.0	6.7
500–1000 employees	0.7	8.0	8.0	0.7	3.3	14.0
>1000 employees	18.0	23.3	34.2	15.3	8.0	50.0
Total	18.7	34.1	47.1	16.0	13.3	70.7
Sector						
Manufacture of food, beverages and tobacco products	0.1	3.1	9.8	0.7	0.7	7.1
Manufacture of textiles and leather products	0	1.0	1.9	0.0	0.0	4.3
Manufacture of wood and furniture, paper and paper products	0.6	0.6	2.0	0.7	0.0	2.9
Manufacture of coke, petroleum and chemicals	3.6	5.1	5.1	2.9	2.1	10.0
Manufacture of pharmaceutical products	3.2	0.7	1.8	2.9	0.7	2.1

Manufacture of rubber and plastic products	0.6	1.6	2.0	0.7	0.0	3.6
Manufacture of basic metals and metal products	2.0	2.0	4.0	2.1	1.4	5.0
Manufacture of computer, electrical equipment and optical products	4.7	3.3	3.3	4.3	3.6	5.0
Manufacture of machinery, vehicles and equipment	3.1	7.8	8.7	2.1	4.3	12.9
Other manufacturing	3.4	3.2	10.3	2.9	2.1	12.9
Total, all	21.3	28.4	48.9	19.3	15.0	65.7
Higher technology industries, total	14.6	16.9	18.9	12.1	10.7	30.0
Lower technology industries, total	6.7	11.5	30	7.1	4.3	35.7

Note: Sector assignments are based on UK Standard Industrial Classification 2007 (UK SIC 2007) major manufacturing sector groupings. The higher and lower technology industries were categorised according to R&D intensities within different industries (Grimpe and Sofka, 2009; OECD, 2011).

7. RESULTS

Table 5.3. shows estimates of both balance between single country and international knowledge and balance between international internal and external knowledge and total factor productivity as the dependent variable. The results presented in column 1 refer to the first hypothesis (H5.1.) which suggests that MNEs which combine single country and international knowledge creation strategies in a balanced way in the overall knowledge creation strategy will experience higher performance. We find that the balance between single country and international knowledge shows a positive and significant effect on TFP (β=.014, p<.001) (Model 1, column 1, Table 5.3.). Thus, hypothesis one (H5.1.) is supported.

The second hypothesis suggests that MNEs which combine international internal and external knowledge creation strategies in a balanced way in the overall international knowledge creation strategy will experience higher performance. We find that the balance between international internal and external knowledge has a positive and significant effect on TFP (β=.008, p<.01) (Model 2, column 2, Table 5.3.). Therefore, the second hypothesis (H5.2.) is also confirmed.

Apart from the main independent variables the lagged dependent variable which was used as predictor, following system GMM literature (Roodman, 2009), shows a positive and significant impact on TFP (p<.001) as well as the product diversity and firm size control variables (Table 5.3.). Firm age shows a significantly negative effect on TFP (Table 5.3.).

All models were checked for autocorrelation which was not present (AR2 value is insignificant) and the difference-in-Hansen tests of exogeneity of instrument subsets showed that instruments are adequate (Roodman, 2009). We also use the difference-in-Hansen test for subgroups to check for exogeneity of a particular variable. Endogenous variables were instrumenting themselves by using the closest lags. To check for the suitability of the model, we run Wald tests for all independent variables (Roodman, 2009). In both models the Wald tests show that the independent variables are important for the model (Appendix 8 and 9).

7.1. Robustness checks

To check the consistency of the above presented results we firstly confirm the same effects by testing the hypotheses on different indicators of firm performance used in prior studies, turnover (sales), labour productivity and operating profit. Table 5.4. below presents the results. The coefficients in the models largely follow the main results. When MNE turnover is used as dependent variable coefficients for both independents follow the results from the main model, both variables are found to be positive and significant. Using labour productivity and

operating profit as dependent variables also confirmed the consistency of the results as both independent variables of focus are positively and significantly related to both dependents, although with slightly lower significance ($p<.01$).

We also run the models using OLS and random effects panel regression (showed by Hausman test as appropriate, Appendix 4). The OLS models show that balance of single country and international knowledge has a positive and significant effect on TFP ($p<.001$) and balance of international internal and external knowledge coefficient is also positive and significant ($p<.001$) (Appendix 10). Also, the coefficients are positive and significant in random effects models (Appendix 10) (Pindado and Requejo, 2012). In conclusion, the main results are fairly robust to other specification methods and other measures of operational performance.

Table 5.2. above showed that there are differences between the higher and lower technology grouping regarding the ways in which different strategies of knowledge creation can be combined. Higher technology MNEs combined both single country and international and international internal and external knowledge creation strategies in a highly balanced and medium balanced way more than the lower technology grouping. Based on this, we run the models again on the split samples of higher and lower technology grouping to check for differences. The results are presented in Appendix 11 and suggest that the performance effects of a balanced combination of single country and international and international internal and external knowledge creation strategies are similar for both groupings and follow the average effects for the manufacturing industry as a whole illustrated by the main results in Table 5.3. These findings also contribute to the robustness of the main results.

Finally, since we reversed the main independent variables, we checked whether the effect was similar if we used the direct value of the absolute differences between two knowledge creation strategies (section 4.2.). The coefficients and significance were the same, but with opposite signs (negative). Therefore, we conclude that the reversing process did not affect the original measures.

Table 5.3. The effect of balance between single country and international knowledge creation and the balance between international internal and external knowledge creation on TFP

	Hypothesis	Model 1	Model 2
Dependent variable:		TFP	TFP
		(1)	(2)
Independents			
Lagged dependent variable		.880***	.896***
		(.005)	(.005)
Balance single country/international patents	H5.1.	**.014*** **	
		(.002)	
Balance international internal/ external patents	H5.2.		**.008** **
			(.002)
Controls			
Single country patents			-.004
			(.003)
Product diversity		.038***	.031***
		(.006)	(.003)
Number of countries		-.008*	-.008†
in which MNE operates		(.004)	(.004)
Intangible Assets		-.001	.001
		(.001)	(.001)
Age		-.023***	-.023***
		(.006)	(.006)

Size (dummy)	.099***	.094***
	(.011)	(.010)
Time (dummy)	Included	Included
Industry (dummy)	Included	Included
(Constant)	1.412***	1.301***
	(.081)	(.073)
AR(2) z-value	-1.09	-1.40
Sargan test	254.31	282.58
Hansen test	114.09	115.45
Number of instruments	111	113
F value	462.87	604.73
Number of observations	1350	1251
Estimation method	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors are in parentheses. Lagged dependent variable, Intangible assets and knowledge based independents were considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets. For testing model 2 a reduced sample was used, 11 MNEs which did not record any international patents in the period were excluded.

Table 5.4. The effect of balance between single country and international knowledge creation and the balance between international internal and external knowledge creation on turnover (sales), labour productivity and operating profit

	Hypothesis	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Dependent variable:		Turnover/ Sales	Turnover/ Sales	Labour Productivity	Labour Productivity	Operating Profit	Operating Profit
		(1)	(2)	(3)	(4)	(5)	(6)
Independents							
Lagged dependent variable		.676***	.681***	.612***	.565***	.436***	.471***
		(.016)	(.017)	(.010)	(.011)	(.010)	(.003)
Total Assets/ Total Assets per Employee		.001	.001	.021***	.018***	.044***	.047***
		(.001)	(.001)	(.001)	(.001)	(.006)	(.003)
Number of Employees		.208 ***	.206***			.960***	.484***
		(.027)	(.025)			(.141)	(.065)
Balance single country/international patents	H5.1.	**.016*** **		**.019*** **		**.006** **	
		(.003)		**(.003)**		(.018)	
Balance international internal/ external patents	H5.2.		**.010** **		**.016*** **		**.113* **
			(.013)		**(.001)**		**(.013)**
Controls							
Single country patents			-0.39***		-.076**		.075*
			(.001)		(.008)		(.026)
Product diversity		-.089**	-.095**	-.211***	-.258**	-.553**	-.224*
		(.032)	(.027)	(.028)	(.021)	(.178)	(.009)

Number of countries	-.129***	-.106***	-.213***	-.236***	-.195†	-.189**
in which MNE operates	(.013)	(.021)	(.015)	(.014)	(.095)	(.050)
Intangible Assets	-.004*	-.001	-.032**	-.034*	.028**	.001
	(.002)	(.002)	(.001)	(.001)	(.008)	(.004)
Age	-.008	-.001	-.005*	-.053	.244*	.236**
	(.023)	(.021)	(.056)	(.027)	(.115)	(.065)
Size (dummy)	.451***	.413***	.536***	.588***	-.058	-.116
	(.039)	(.036)	(.030)	(.024)	(.130)	(.098)
Time (dummy)	Included	Included	Included	Included	Included	Included
Industry (dummy)	Included	Included	Included	Included	Included	Included
(Constant)	2.873***	2.756***	2.925***	3.494***	-2.356*	1.338*
	(.016)	(.216)	(.156)	(.181)	(.204)	(.657)
AR(2) z-value	-0.02	-0.04	0.64	-0.08	1.20	0.72
Sargan test	548.69	551.01	366.44	418.98	140.60	166.09
Hansen test	85.19	91.93	116.25	116.17	112.46	125.12
Number of instruments	98	99	132	135	127	144
F value	588.00	690.30	292.10	199.25	96.83	191.51
Number of observations	1350	1251	1350	1251	1350	1251
Estimation method	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors are in parentheses. Lagged dependent variable, Intangible assets and knowledge based independents were considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets. For testing model 2 a reduced sample was used, 11 MNEs which did not record any international patents in the period were excluded.

8. DISCUSSION AND CONCLUSION

Although prior research argued that international knowledge plays a fundamental role in MNE performance (Berry, 2014; Gupta and Govindarajan, 2000; Kogut and Zander, 1992; Kogut and Zander, 1993; Patel et al., 2014; Van de Vrande, 2013) and emphasised that MNEs create knowledge using international strategies more frequently (Berry, 2014; Yamin and Otto, 2004), there hasn't yet been sufficient examination of how international knowledge creation strategies specifically fit in the MNE's overall knowledge creation strategy. The question why and to what extent MNEs allocate their scarce resources towards international knowledge creation strategies as opposed to single country knowledge creation was not analysed in detail.

In addition, extant research acknowledged that MNEs can create knowledge using different international strategies (Kogut and Zander, 1992; Kogut and Zander, 1993), but did not specifically consider their positioning in the MNE's overall knowledge creation strategy and what this means for MNE performance. Moreover, since studies have not thoroughly analysed how international knowledge creation strategies fit in the overall MNE strategy we are not able to precisely differentiate between MNEs which devote a higher share of resources to different international knowledge creation strategies and those that devote a lower share. This limits our understanding of whether and how MNEs may differ based on the importance they put on international knowledge creation and its different types compared to other strategies which MNEs may use to create knowledge. In other words, variations in MNE performance may be explained by the way in which firms combine international with other knowledge creation strategies.

8.1. Theoretical and practical implications

This chapter extends our understanding of the specific position that international knowledge creation and its different strategies hold in the overall MNE knowledge strategy. By considering whether and how MNEs combine international with single country knowledge creation and different international knowledge creation strategies (internal and external), we are able to draw conclusions regarding its importance within the whole MNE. In this view, we extend knowledge creation studies which did not show the specific ways in which MNEs can build their performance by combining different international knowledge creation strategies.

We argue that combining international with single country knowledge creation in a balanced way can lead to higher performance by enabling the firm to access new knowledge while, at the same time, minimising the risk of imitation of the firm's core knowledge assets. Furthermore, we suggest that MNEs should allocate resources devoted to international knowledge creation between its two strategies, internal and external, in a balanced way which

will ensure that the newly accessed knowledge is transferred and exploited more successfully and will have a positive impact on MNE performance. The results of the analyses support these arguments.

Extant literature examining the influence of knowledge on performance has highlighted a tension between different knowledge creation strategies which tend to outcompete each other for scarce resources (Birkinshaw and Hood, 1998; Gibson and Birkinshaw, 2004; Tushman and O'Reilly III, 1996). Also, these studies argue that MNE subsidiaries have a tendency to focus and specialise their knowledge creation routines based on initial success of a particular strategy and try to attain more knowledge resources (Birkinshaw and Hood, 1998; Gupta et al., 2006). However, the findings show that, on MNE level, firms should encourage specialisation only to a limit as the performance benefits are higher if the MNE creates knowledge using different strategies simultaneously and divides resources and efforts between them in a balanced way.

This study therefore emphasizes the importance of combining, rather than prioritising between different knowledge creation strategies in the MNE, following prior studies which argue for a simultaneous combination of different knowledge in the firm (Bogers and West, 2012; Cassiman and Veugelers, 2006; Grimpe and Kaiser, 2010; Lewin et al., 2011; Lokshin et al., 2008; March, 1991; Nicholls‐Nixon and Woo, 2003). These studies argue, for instance, that internal and external knowledge are complementary and the returns to one increase as the firm engages more intensely in the other (Cassiman and Veugelers, 2006; Grimpe and Kaiser, 2010; Lokshin et al., 2008). However, the added value of this study is that it goes beyond arguing that MNEs should simultaneously engage in different knowledge creation strategies, it specifically shows that MNEs should combine particular international knowledge creation strategies in a balanced way in order to achieve higher performance. By doing this, we add to a more in-depth understanding of how and why MNEs would undertake the challenge of creating knowledge using diverse strategies.

By looking at how firms distribute their knowledge creation efforts between internal and external international knowledge creation strategies we specifically add to the discussion regarding international knowledge creation in MNEs, which, to the best of our knowledge was not studied in this specific context. Prior studies which looked at how firms combine internal and external knowledge and showed that a combination between the two is positively related to performance (Cassiman and Veugelers, 2006; He and Wong, 2004) did not examine whether this is true in case of internal and external international knowledge creation specifically. This study shows that this is indeed the case also for international, knowledge creation: MNEs need to employ both strategies and they need to do this in a balanced way, simultaneously pursuing the two, in order to achieve the desired positive productivity effect

on the level of the whole group. We show that the differences between the combinations of environments in which firms create their international knowledge constitute the unique and idiosyncratic situations which may help build higher performance.

Also, our empirical approach follows most recent definitions of international knowledge creation. Specifically, we look at the distribution of single country and international knowledge creation as the difference between one country and multi-country knowledge, following most recent studies (Berry, 2014), which can be distinguished from studies which looked at international knowledge as all knowledge outside the focal unit or country of operation (Almeida, 1996; Lahiri, 2010; Leiponen and Helfat, 2010; Rothaermel and Alexandre, 2009).

From a practical perspective, this study provides guidelines for managers who make critical choices regarding the different strategies of knowledge creation and their representativeness within the overall knowledge creation strategy of the MNE.

We show that single country knowledge creation must be complemented simultaneously with a rather equal share of international knowledge in order to have a positive performance effect. Also, managers need to divide their international knowledge resources and efforts equally between the two international strategies, they need to create knowledge in form of multi-country collaborations with other units within the MNE as well as in collaborations with external partners from other countries. A balance between these strategies will help them target the desired performance effect.

9. LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH

This study tests the value of balanced combinations of different knowledge creation strategies on the group level. It would be useful to analyse, especially with regards to the international part of the knowledge creating portfolio, whether the balanced combinations also occur on the team and individual level (Raisch et al., 2009) and their value for the unit. Looking at balance of internal and external knowledge creation at lower organisational levels would give insight into the ways in which balancing happens within the unit and would give the opportunity to study its impacts. As emphasised in prior literature, it is unclear whether different teams are specialised for certain knowledge creation strategies or the same individuals participate in different knowledge creation strategies (Raisch et al., 2009).

In addition, we do not address the issue of quality of knowledge creation as due to time constraints this was beyond the scope of this research project. Patents differ in their significance and therefore, not all knowledge creation will have the same potential impact on

performance (Griliches, 1998b). However, it is an important issue as studies showed that conclusions regarding benefits from knowledge creation might be more complex if the issue of quality of a firm's knowledge is taken into account (Singh, 2008). Also, combinations of different knowledge creation strategies may be used to target different types of technologies (March, 1991; Van de Vrande, 2013), thereby stressing the importance to look at whether these balanced combinations bring the most beneficial mix of different technologies.

Apart from the issue of knowledge creation quality and technology type, we do not consider the exact form of collaboration for internal and external international knowledge creation. Patents can be viewed as an outcome of different types of collaboration such as alliances, joint ventures or less formal R&D collaborations between partners. A recent study showed that the performance implications of having a diversified knowledge creation portfolio depend on whether it covers a broad spectrum of knowledge strategies (Van de Vrande, 2013). In this view, it would be useful to examine the different collaboration forms which MNEs use to achieve a balance of international knowledge strategies.

Similarly, we do not consider other features of the knowledge created. For instance, prior studies showed that the attributes of knowledge such as tacitness matter in determining their value (Kogut and Zander, 1992; Kogut and Zander, 1993). Specifically, a recent study showed that a combination of internal and external knowledge reinforces the positive impact on performance if the knowledge is more tacit (Yamin and Otto, 2004). Therefore, the features of particular patents created using international knowledge creation strategies may affect the value of combining different strategies.

Furthermore, portfolio theory argues that knowledge creation strategies as options may be sub- or super-additive based on the overlap of their characteristics (Vassolo et al., 2004), which we do not consider. Apart from just testing the combinations of different knowledge creation strategies in the MNE, future studies may wish to pursue a richer analysis by looking at their characteristics in more detail and analyse whether and how they overlap. For instance, if a firm opts for a balanced combination of international internal and external patents, it may still be sub-additive for performance if the same units are engaged in international internal knowledge creation or if the partners in international external knowledge creation operate in similar countries. These similarities may limit the diversity of knowledge the firm can access and therefore, these knowledge creation strategies may be sub-additive.

An interesting extension of these ideas would be to search for and analyse MNE characteristics that would have an effect on the value of combining different knowledge creation strategies. There may be a MNE specific context that would support these relationships. For instance, a

study showed that decision making in the firm is an important factor (Cassiman and Veugelers, 2006). Other factors such as absorptive capacity may support the positive performance effect of combining internal and external international knowledge creation (Cassiman and Veugelers, 2006; Lokshin et al., 2008). Also, theory suggests that knowledge creation decisions in the MNE may depend on the opportunistic behaviour of units (Birkinshaw and Hood, 1998; He and Wong, 2004; Tushman and O'Reilly III, 1996). Therefore, it would be interesting to analyse whether combinations of knowledge creation strategies on MNE level are actually an outcome of internal competition of resources based on opportunistic behaviour of units which specialise in different knowledge creation strategies.

Finally, the conclusions made here are restricted by the sample and time period selected. Further research might take into account MNEs that are headquartered in other countries, especially emerging countries and test the effects mentioned.

CHAPTER VI

THE MODERATING EFFECT OF ENVIRONMENTAL INSTABILITY

1. INTRODUCTION

Previous chapters offered hypotheses based on the assumption that MNEs are efficient actors which make choices based on similar information and equal levels of risk and perception of change in the environment they operate. In this way, MNEs which opt for similar levels of international knowledge creation strategies or combinations of strategies will experience similar performance. However, theory suggests that instability in the MNE's environment can define the MNE's choices of knowledge creation strategies, may condition the way in which MNEs develop their knowledge creation capabilities and ultimately may moderate the value of knowledge creation strategies or combinations of strategies (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993).

Environmental instability is a context-specific factor defined as the rate of change or degree of volatility which can result from different sources of disequilibrium such as a significant change of the competitive or technological conditions (Child, 1972; Dess and Beard, 1984; Simerly and Li, 2000). It represents one of the main characteristics of the environment within which the firm operates (Child, 1972; Dess and Beard, 1984; Keats and Hitt, 1988; Simerly and Li, 2000).

Environments can either be more unstable and changing continuously or more stable and predictable (Dess and Beard, 1984; Li and Atuahene-Gima, 2001; Lichtenthaler, 2009). Instability is widely accepted in the literature as a significant determinant of the benefits of knowledge (Jansen et al., 2006; Levinthal and March, 1993; Li and Atuahene-Gima, 2001; Lichtenthaler, 2009). Unstable environments make existing knowledge creation strategies obsolete and require MNEs to adapt and change their knowledge creation models, whereas in more stable environments knowledge creation models are more constant (Levinthal and March, 1993; March, 1991).

Specifically, knowledge of the firm argues that MNEs which operate in unstable environments are pressured to survive and as a consequence engage more in external knowledge creation as they try to access knowledge they need faster and in a less costly way (Kogut and Zander, 1992). Also, unstable and highly competitive environments urge the MNE to upgrade and sharpen its knowledge creation capabilities more (Birkinshaw and Hood, 1998). In these conditions it is important for MNEs to invest more in its knowledge creation capabilities which enable them to leverage know-how and information of the whole group more efficiently

(Birkinshaw and Hood, 1998; Cui et al., 2005; Kogut and Zander, 1992; Kogut and Zander, 1993). Moreover, there is evidence that the impact of specific knowledge on performance such as product innovation and the value of specific types of learning such as exploration are defined by the instability of the firm's environment (Li and Atuahene-Gima, 2001; Lichtenthaler, 2009).

These arguments suggest that environmental instability may also have an impact on the extent to which certain strategies and combinations of strategies of international knowledge creation affect MNE performance. However, whether and in which way environmental instability determines the value of knowledge creation with different locational and organisational origin was not fully addressed in prior literature. What we do not know in particular is how instability defines the performance effect of international internal and external knowledge creation. Also, we do not know whether specific combinations of single country and international and international internal and external knowledge creation in the overall MNE knowledge strategy are more beneficial in specific environments.

Based on these arguments, it may be the case that two MNEs which share similar knowledge creation strategies and combine them in a similar way still experience differences in performance that cannot be explained just by analysing the levels of knowledge creation strategies. In other words, firms operating in contexts characterised by specific environmental instability will opt for distinct knowledge creation strategies or their combination, which will bring them specific performance advantages.

In order to address this, we combine insights from knowledge theory of the firm and MNE subsidiary evolution with insights regarding the effects of instability introduced by innovation theory to provide a wider understanding how benefits from international knowledge creation strategies vary within environments characterised by different levels of instability. We suggest that an understanding of this relationship helps in explaining why some firms, by responding to changes in the environment, are able to benefit more effectively from their knowledge creation strategies than others. In this way, we add to the theoretical and empirical discussion in the literature regarding the effect of the environment on the knowledge and performance relationship (Benner and Tushman, 2003; Gupta et al., 2006; Jansen et al., 2006; Kogut and Zander, 1992; Kogut and Zander, 1993; Zahra, 1996) and contribute to a better understanding of how MNEs benefit from different knowledge creation strategies and their combinations in environments characterised by different levels of instability.

We differ from prior studies by focusing on different international knowledge creation strategies and their combinations. As emphasised by recent studies, many aspects regarding

how MNEs combine and coordinate knowledge under different environmental conditions remains unexplored (Jansen et al., 2006). Also, we aim to show the effect of environmental instability on the relationship between international knowledge creation strategies and MNE group performance specifically, which can be distinguished from other studies that examined similar effects on unit level (Jansen et al., 2006; Zahra, 1996).

The results, based on the analysis of 46,712 innovations of 150 UK-headquartered MNEs and their 5,352 first level subsidiaries in the 2003 to 2012 period show that environmental instability moderates the relationship between both international internal and external knowledge creation and MNE performance. It also moderates the performance effect of different combinations of international knowledge creation strategies in the MNE.

2. THEORY AND HYPOTHESES

MNEs may operate in very specific environments characterised by the unpredictability of major changes in the field. Consequently, particular environments can be unstable if the changes are more frequent and unpredictable or stable if the changes are less frequent and expected (Dess and Beard, 1984; Jaworski and Kohli, 1993; Klevorick et al., 1995; Li and Atuahene-Gima, 2001; Lichtenthaler, 2009). Hence, specific knowledge creation strategies may lead to different outcomes in different environments (Birkinshaw and Hood, 1998; Jansen et al., 2006; Kogut and Zander, 1992; Kogut and Zander, 1993; Levinthal and March, 1993; Li and Atuahene-Gima, 2001; Lichtenthaler, 2009). In fact, studies argue that the most appropriate knowledge creation strategies can be selected only if aligned with the features of the environment (Jansen et al., 2006; Kogut and Zander, 1992; Miller and Friesen, 1983; Zahra, 1996; Zahra and Bogner, 2000).

Generally, the conditions in highly unstable environments are difficult to predict which increases risk, whereas in stable environments there is an established set of technologies and knowledge creation models that the firms use. Increasing levels of environmental instability requires the firm to change its established models of creating knowledge (Duncan, 1972; Levinthal and March, 1993). Studies showed that even established organisations find it challenging to keep pace with the instability of the environment which causes their knowledge creation to become increasingly outdated (Sørensen and Stuart, 2000). Instability in the environment forces the firm to adjust its operations and pursue new opportunities in order to survive (Levinthal and March, 1993). In this view, firms that operate in similar technological fields or specialise and focus in their knowledge processes are in particular vulnerable to changes in the environment because they cannot adapt fast (Levinthal and March, 1993; March,

1991). In this way, the instability of an environment will demand a constant re-invention of the firm's knowledge creation strategies.

According to these arguments, the choice of knowledge creation strategies and their value will ultimately depend on the characteristics of the MNE's environment. The following sections explore the potential moderating effect of environmental instability on the relationship between knowledge creation of different locational and organisational origins and their combination and MNE performance.

2.1. The moderating effect of environmental instability on the relationship between international internal and external knowledge creation and MNE performance

Knowledge of the firm and subsidiary evolution theory suggest that organisations which prosper under unstable conditions are the ones which adapt, specialise and develop their knowledge creation capabilities in a speedy and efficient manner by using information from the external environment (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Levinthal and March, 1993). In this view, environmental instability is expected to influence the relationship between international internal and external knowledge creation and MNE performance based on two mechanisms: firstly by pressuring the firm to rapidly substitute its established models of creating knowledge with the most suitable new models and secondly by demanding stronger knowledge creating capabilities which enable the MNE as a whole to recognise and pursue new opportunities even under unstable and uncertain conditions (Birkinshaw and Hood, 1998; Kogut and Zander, 1992).

International internal knowledge creation can be argued as particularly beneficial in unstable environments. Since it has a cross-unit, multi-country dimension, this strategy gives the whole MNE access to knowledge creation models of specific subsidiaries that operate in different countries. These knowledge creation models are transferred to other MNE subsidiaries through international internal knowledge creation (Kogut and Zander, 1992; Kogut and Zander, 1993). Therefore, international internal knowledge creation provides the MNE as a whole a combination of different knowledge creation models, which enable the firm to adapt and refocus to more suitable knowledge creation models when conditions in the environment change.

Apart from accessing different knowledge creation models, international internal knowledge creation is crucial also because it enables the MNE to replace outdated models more rapidly. Since this knowledge strategy brings together knowledge creation models of different subsidiaries belonging to the same MNE, they also share similar values and therefore there is

a degree of similarity in their knowledge creation which means that the MNE will be able to shift to other knowledge creation models more rapidly than if these models were, for instance, based on external knowledge creation.

International external knowledge creation can also be argued as specifically beneficial in unstable environments as this strategy ensures MNEs, based on information gathered from external co-creators operating in different countries, have a richer knowledge base and stronger knowledge creation capabilities with more opportunities to create new knowledge even when conditions significantly change (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993; Lichtenthaler, 2009; Zahra, 1996). Due to increasing uncertainty, firms operating in unstable environments benefit from a wider pool of knowledge gained from engaging in international external knowledge creation. Specifically, a richer knowledge base on MNE level is important because it gives the MNE more options to choose from when attempting to create knowledge in environments that constantly change (Kogut and Zander, 1992; Kogut and Zander, 1993). The variety of information the firm has access to through this strategy in particular brings a higher probability that some of the ideas will be applicable in the changed environment. MNEs which have access to different knowledge from different countries, partners and possibly technological fields do not limit their focus to specific knowledge processes and therefore are less vulnerable to changes in the environment (Levinthal and March, 1993; March, 1991).

Also, in unstable environments there is greater demand for strong internal capabilities in order to create knowledge of higher value in the future, whereas MNEs operating in stable environments are able to do the same based on a lower level of internal capacity (Grimpe and Sofka, 2009; Lu and Beamish, 2004). It is the superior access to new knowledge that the MNE has by engaging in international external knowledge creation which alters the knowledge base of the whole MNE and builds stronger knowledge creation capabilities of their units, which as an outcome are more adept to build new knowledge (Kogut and Zander, 1992). Accessing different partner and country specific know-how through international external knowledge creation improves the capability of the firm to assimilate new knowledge and recognize opportunities (Birkinshaw and Hood, 1998; Cohen and Levinthal, 1990; Lewin et al., 1999).

Environmental instability also requires the MNE to intensify their activities in pursuit of new models and information through different external knowledge strategies such as knowledge based alliances or co-operation projects (Lewin et al., 1999). This also builds knowledge creation capabilities (Birkinshaw and Hood, 1998). All of the above suggests that international external knowledge may play a more significant role in unstable environments by providing a more robust platform for re-inventing knowledge creation strategies under conditions of

constant change (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993).

In contrast, MNEs operating in environments which do not change often will benefit less from these two international knowledge creation strategies. Stable environments are related to incremental knowledge creation projects and applied research (Jansen et al., 2006; Santamaría et al., 2009). In these environments, MNEs focus more on more simpler knowledge creation using established information, models and processes (Arora et al., 2014). What is important in stable environments is the use of most advanced design, machinery and training rather than creating radical new knowledge (Santamaría et al., 2009; Thornhill, 2006).

The models of knowledge creation in stable environments focus on the same technological field, involve significantly less cost and can materialise in a more timely fashion (Grimpe and Sofka, 2009; Thornhill, 2006). MNEs operating in stable environments conduct research that is often market specific and directly related to the country location in which it is applied and they are less likely to engage in complex research with other international units and external partners than MNEs operating in more unstable environments (Arora et al., 2014) Firms in stable environments base their knowledge activities on similar approaches using simple market inputs such as information from consumers and therefore they do not have the need to possess superior knowledge creation capabilities (Birkinshaw and Hood, 1998; Grimpe and Sofka, 2009). The pressure to develop their capabilities is very low (Birkinshaw and Hood, 1998).

Also, because of the market specific nature of knowledge in stable environments, MNEs may incur greater transaction costs when transferring and implementing new knowledge created across the group (Argyres and Silverman, 2004; Kogut and Zander, 1992; Kogut and Zander, 1993). Since it is highly specialised, knowledge is directly less useful to other units and it requires additional research efforts to find new applications for it. Hence, there is a higher probability that firms in more stable environments will find international internal and external knowledge creation strategies less useful and focus more on single country knowledge creation which is location specific. Finally, because stable environments are characterised with established models of knowledge creation that rarely change, there are less opportunities for the firm to materialise on a wider pool of knowledge which can be accessed by engaging in international knowledge creation strategies (Kogut and Zander, 1992; Lewin et al., 1999).

The above arguments bring to the conclusion that international internal and external knowledge creation strategies are specifically crucial in unstable environments. These strategies enable the MNE to quickly switch to the most suitable models of creating knowledge. Also, they give the MNE the best chance of building an extensive knowledge base which

makes the firm more flexible in adapting new models of knowledge creation and they add to the firm's internal capacity which brings a higher probability that the firm will recognise new opportunities even in unstable and uncertain environments. In this view, the instability of the environment would moderate the initial curvilinear relationship between both internal and external international knowledge creation and operational performance found in the fourth chapter. The hypotheses are:

Hypothesis 1: Environmental instability moderates the curvilinear (U-shaped) relationship between international internal knowledge creation and MNE group performance in such a way that MNEs operating in more unstable environments will benefit more from higher levels of international internal knowledge creation. (H6.1.)

Hypothesis 2: Environmental instability moderates the curvilinear (U-shaped) relationship between international external knowledge creation and MNE group performance in such a way that MNEs operating in more unstable environments will benefit more from higher levels of international external knowledge creation. (H6.2.)

2.2. The moderating effect of environmental instability on the balance between single country and international knowledge creation and international internal and external knowledge creation and MNE performance

Apart from moderating the exact levels of different international knowledge creation strategies, environmental instability may also influence the way in which MNEs combine different knowledge creation strategies. The combinations of different knowledge creation strategies and how MNEs can balance or prioritise between them has been discussed in detail in chapter five. However, it may be the case that MNEs which combine knowledge creation strategies in a similar way might still experience differences in performance because they operate in either unstable or stable environments.

As in previous section, knowledge of the firm and subsidiary evolution theory suggest environmental instability is expected to moderate the value of combining different knowledge creation strategies within the MNE based on two mechanisms: by determining the scope of knowledge the firm should have access to in order to increase its flexibility in adapting established models of knowledge creation and by demanding stronger knowledge creating capabilities necessary to create new valuable knowledge (Kogut and Zander 1992; Birkinshaw and Hood, 1998).

Previous research argued that in conditions of instability and constant change specifically it is beneficial to pursue different strategies of knowledge simultaneously in order to secure access

to different options which may be critical when a shift in the technological field occurs (Gupta et al., 2006; Levinthal and March, 1993; March, 1991). These researchers warn that firms which do not differentiate their knowledge will ultimately lose their competitiveness in unstable environments because of the inability to adapt and find new more suitable solutions. Their reasoning is based on the argument that overspecialisation will lead to the underutilization of new opportunities, which is central to survival in unstable environments (Levinthal and March, 1993; March, 1991).

Still, there are also studies which challenge these views by arguing that pursuing different strategies of knowledge simultaneously may not be valuable and logical in unstable environments (Gupta et al., 2006; Jansen et al., 2006; Uotila et al., 2009). They argue that it might not be effective because in unstable environments in particular the firm is highly dependent on the adoption of new external technologies (Uotila et al., 2009). The need for a broader scope of information and know-how will motivate the firm to focus more on external knowledge compared to internal knowledge. Similarly, in stable environments characterised with incremental change, the firm could depend on its internal technology base for a longer time period and specialise by exploiting familiar and available concepts (Uotila et al., 2009).

As argued in previous chapter, MNEs make choices regarding the ways in which they combine single country and international knowledge creation strategies within the overall MNE knowledge creation strategy. Previous studies showed that firms in more unstable environments are widely involved in single country knowledge creation. They tend to cooperate in local geographic clusters which gives them access to peer knowledge externalities (Audretsch and Feldman, 1996; Cantwell and Piscitello, 2002) and provide opportunities for efficiency, specialization and in-depth problem-solving by sharing of knowledge and costs of new knowledge creation (Kotabe et al., 2007). However, firms in unstable environments will also widely engage in international knowledge creation because these strategies provide access to valuable know-how kept by other organisations in different environments and this wider pool of knowledge is needed to ensure flexibility necessary for developing valuable innovations when the conditions change (Gupta et al., 2006; Levinthal and March, 1993; March, 1991). Therefore, we argue that in unstable environments firms will benefit more if they combine both single country and international knowledge creation. Similarly, in more stable environments characterised with incremental change the firm can achieve higher performance by specialising in only one strategy.

Secondly, MNEs which engage in international knowledge creation need to make choices regarding the ways in which they will combine or prioritise between internal and external international knowledge (discussed in fifth chapter). Environmental instability may have an

influence on the ways in which MNEs combine these strategies and therefore specific combinations may be more or less valuable depending on the extent to which the MNE environment is unstable and unpredictable.

Unstable environments may call for a simultaneous and balanced combination of the two international strategies in particular as both may have valuable implications for MNE knowledge under uncertain conditions. Both bring an inflow of external knowledge, but of different type. International internal knowledge creation gives access to unit specific information regarding particular environments in which the subsidiaries operate, whereas international external knowledge creation enables inflow of knowledge held by other partners such as competitors or research institutes. Therefore, the MNE is able to develop a wider and extensive knowledge base which will provide a plethora of different options for knowledge creation when conditions in the environment change significantly and facilitate the shift to new models (Kogut and Zander, 1992; Kogut and Zander, 1993).

Also, combining the two strategies in a balanced way may contribute to building better knowledge creation capabilities which enable the MNE to create new knowledge more effectively (Birkinshaw and Hood, 1998). This is crucial under unstable environmental conditions (Kogut and Zander, 1992). By engaging in internal international knowledge creation as well as external, the MNE is able to build an established communication network between its units which makes it easier to utilise the wide scope of know-how the firms has access to through external international knowledge creation (Gupta and Govindarajan, 2000). A constant pursuit to gather external information without recycling it internally will result in too many unrelated and undistinctive research directions which the firm is not able to efficiently pursue when the conditions change, causing significant resource loss (Levinthal and March, 1993; March, 1991). If more units participate in internal international knowledge creation, the probability that new external knowledge will be recycled in a fast and effective way is higher because the units are more familiar with each other's knowledge processes, which may determine the MNE's success when conditions change. In this view, unstable environments in particular may call for both strategies to be represented in the overall knowledge creation strategy in a balanced way, whereas a precondition for the MNE to successfully operate in more stable environments would be to focus on just one as the firm is not pressured to further develop its knowledge creation capabilities (Kogut and Zander, 1992).

Based on the arguments in this section, we hypothesise:

Hypothesis 3: Environmental instability moderates the positive relationship between a balanced combination of single country and international knowledge creation and MNE

group performance in such a way that MNEs operating in more unstable environments will benefit more from a balanced combination of single country and international knowledge creation. (H6.3.)

Hypothesis 4: Environmental instability moderates the positive relationship between a balanced combination of international internal and external knowledge creation and MNE group performance in such a way that MNEs operating in more unstable environments will benefit more from a balanced combination of international internal and external knowledge creation. (H6.4.)

3. DESCRIPTION OF THE DATA

This section follows the data description outlined in the fourth and fifth chapter. The sample includes 150 MNEs and 5,352 first level subsidiaries which recorded in total 46,712 knowledge creation projects in form of patents granted during the 2003 to 2012 period. Both the firm level and panel data structure choice is explained in section 4 of the fourth chapter.

3.1. Data sources and sample

Following the same data collection procedure outlined in the fourth and fifth chapter, firm level panel data was collected using two sources, Bureau Van Dijk Fame database for financial and organisational structure information for the consolidated MNE groups and European Patent Office (EPO) Espacenet database for the patent information for the parents and each of the first level units as in prior studies (Arora et al., 2014; Brouthers, 2002; Reitzig and Wagner, 2010; Salomon and Jin, 2010). Both are discussed in detail in section 4 of the fourth chapter.

4. VARIABLES

4.1. Dependent variable

As in previous two chapters and in similar studies, the dependent variable is MNE group performance measured as *Total factor productivity (TFP)* with the main aim of identifying the share of productivity growth in MNEs as a consequence of implementing particular knowledge creation strategies (Driffield et al., 2010; Javorcik, 2004; Liu et al., 2009). The variable was operationalised as the Cobb-Douglas production function residual using the same established approach as in previous two chapters (Adams and Jaffe, 1996; Griliches, 1992; Kafouros et al., 2008; Liu et al., 2009; Scherer, 1982). The production function is based on factor inputs of assets, number of employees and year and industry dummies, expressed by equation 4.1. in section 5 of the fourth chapter and in accordance to standard methodology (Javorcik, 2004; Temouri et al., 2008). As in previous chapters, the equation was estimated

using system GMM, the relevance of which is discussed in detail in section 5 of the fourth chapter.

4.2. Independent variables

The independent variables used to test the hypotheses in this chapter are knowledge related measures for which patent assignment information is used as proxy. The reasons why this measure is superior to others in the context of this research as well as its main advantages and disadvantages are discussed in sections 5.2.1. and 5.2.2 of the fourth chapter. As in previous two chapters, we use the affiliate-parent relationships from the Fame database and the applicant name and address stated on the patent document to identify the specific strategy which was used by each of the units and headquarters to create each specific patent, as in prior studies (Arora et al., 2014). The approach is discussed in detail in section 5.2.3 of the fourth chapter.

International internal knowledge creation was operationalised using expression 4.2. introduced in the fourth chapter. As in the mentioned chapter, we use a simple count of patents developed internationally within the MNE (in collaboration with different units) for each unit and headquarters and divide the figure by the total number of international patents for each unit. In the final step this unit level ratio is divided by the number of knowledge intensive units in the MNE in order to obtain the MNE level indicator.

Using expression 4.3. introduced in the fourth chapter, *International external knowledge creation* is operationalised using the share of international patents created in collaboration between one (or more) units within the MNE and at least one external partner operating in a different country in total international patents. Firstly we estimate the unit level share and then average it by the number of knowledge creating units, which results in MNE level information.

Hypotheses 6.3. and 6.4. examine the moderating effect of environmental instability on balanced combinations of different knowledge strategies in the MNE which were discussed in detail in the fifth chapter. As in previous chapter, we estimate two types of balanced combinations of knowledge creation strategies. Firstly, *Balance between single country and international knowledge creation* defined using expression 5.1. introduced in the fifth chapter as the absolute difference between the ratios of single country and international knowledge creation in total. The higher the difference, the lower the balance. Secondly, *Balance between internal and external international knowledge creation* (expression 5.1. introduced in the fifth chapter) measures if there are more external international patents created than internal and vice versa or if they are more equally distributed in the knowledge creating portfolio. It is

defined as the absolute difference between ratios of international internal and external patents in total for each unit and weighted for each MNE.

We define and measure *Environmental instability* following Keats and Hitt (1988) as an indicator which captures the unpredictability of change in for instance customer tastes, technologies or competition in dominant industries. Keats and Hitt (1988) measure it as volatility in sales in the dominant industry for a specific time period, used in a similar way in other studies (Lepak et al., 2003; Snell, 1996). Other authors measured environmental instability using various approaches. Some used a survey based approach and executives' perceptions of the environment, while others used R&D levels as proxy (Li and Atuahene-Gima, 2001; Miller and Friesen, 1983; Zahra, 1996; Zahra and Bogner, 2000).

The most suitable measure for instability in the context of this study would be to estimate changes in R&D levels in dominant industries using firm-level data because it would enable us to examine the effect of technological instability specifically. However, firm level R&D data was available only for a few of the MNEs in the sample through the Fame database. Therefore, we use changes in sales as proxy for environmental instability. Using the same method as in prior studies, we regress time against the natural logarithm of sales for each dominant industry in the selected time period and divide the standard error of the regression slope coefficient by the mean value of sales to estimate the value of instability for each industry for the specific sample (Keats and Hitt, 1988; Lepak et al., 2003). We estimate the values of environmental instability for ten dominant industries within the manufacturing sector. We use the main industry of the MNE group as reference for the industry in which the firm operates. Therefore, we proxy the level of environmental instability as a time invariant industry level variable. A higher variable score indicates greater environmental instability. The original reference uses sales data for a five year time period which preceded the data collection (Keats and Hitt, 1988; Lepak et al., 2003; Snell, 1996). However, since we capture a ten year panel and we do not have access to historical sales data through the main sources, we estimate the value of environmental instability for the whole of the chosen time period. We expect the variable to have a negative direct effect on MNE performance, following prior studies (Lepak et al., 2003).

According to prior literature, an alternative operationalization option for environmental instability is to use an industry dummy, following prior studies (Grimpe and Sofka, 2009; Haleblian and Finkelstein, 1993; Klevorick et al., 1995). Many knowledge studies suggest that instability can be looked at in terms of higher and lower technology industries using specific estimates when firm level R&D data is not available (Grimpe and Sofka, 2009). The distinction between higher and lower technology industries was based on the OECD

Directorate for Science, Technology and Industry's classification of manufacturing industries based on R&D intensities, following prior similar studies (Grimpe and Sofka, 2009) and used also in previous two chapters as a tool for describing the features of the sample. However, we give more merit to the changes in sales proxy, but introduce the industry dummy as a robustness.

Table 6.1. shows the values of the environmental instability variable when proxied using sales and the procedure mentioned above. Also, it shows the two lower and higher technology groupings and the different industries belonging to each group, as well as the distribution of firms and knowledge creation (total patents granted) in these groups.

An important observation is that, although some industries belong to the higher technology grouping according to changes in R&D, their industry level indicator for environmental instability measured using sales is below the mean value of .075 (Table 6.2.), which indicates that although the two proxies for environmental instability are comparable, in certain cases do not classify firms in the same way. Similarly, not all lower technology industries experience below mean values of environmental instability in terms of sales. This indicates that the results although largely similar, may also be different in particular instances and any conclusions should be made with caution. The main general features and representativeness of the sample can be found in section 4 of the fourth chapter.

Table 6.1. Environmental instability, number of firms and patents granted in the dominant manufacturing sector industries

	Number of firms in the sample, out of total (%)	Number of patents in the sample, out of total (%)	Environmental instability indicators, changes in sales as proxy
Higher technology industries			
Manufacture of pharmaceutical products	4.6	10.6	.143
Manufacture of computer, electrical equipment and optical products	11.3	7.2	.043
Manufacture of machinery, vehicles and equipment	18.6	46.3	.177
Manufacture of chemicals and petroleum	14	8.5	.050
Total	48.6	62.1	

Lower technology industries			
Manufacture of food, beverages and tobacco products	23	1.0	.052
Manufacture of textiles and leather products	4	0.1	.058
Manufacture of wood and furniture, paper and paper products	3	0.3	.085
Manufacture of rubber and plastic products	4	0.5	.064
Manufacture of basic metals and metal products	8	5.7	.012
Other manufacturing	16.6	19.8	.047
Total	51.3	37.9	

4.3. Control variables

The models used to test hypotheses also include various control variables emphasised in previous studies as important for studying MNE performance in the context of knowledge creation. They follow the controls selected in previous two chapters. In the initial production function the logarithm of *Total assets* and *Number of employees* was used following prior studies with an expected positive and significant effect (Javorcik, 2004; Temouri et al., 2008). Also, *Product diversity* and *Number of countries in which the firm operates* were introduced and operationalised using the same approach as outlined in section 5.3. of the fourth chapter. Previous studies found a mixed, but significant effect of both on different measures of performance (Lu and Beamish, 2004; Santamaría et al., 2009; Tallman and Li, 1996). Considering hypotheses one and two focus only on international part of the knowledge creating portfolio, we also control for the effects of *Single country patents* or one country knowledge creation, which is operationalised using the same approach as in expression 4.4. in section 5.3. of the fourth chapter. This variable was suggested to have a mixed significant effect (Artz et al., 2010; Bloom and Van Reenen, 2002; Deeds and Decarolis, 1999). *Intangible Assets* is used to control for the effects of other knowledge based resources (Hall, 1993).

Apart of these main controls, we also introduce MNE *Age* (expressed as years of operation) and *Size* (median of sales dummy), both of which proved to have a mixed significant effect (He and Wong, 2004; Lyles and Salk, 1996; Nieto and Rodríguez, 2011; Santamaría et al., 2009; Tallman and Li, 1996). Lastly, we use *Time* and *Industry* dummies to account the effects

of different time and industry within the period (Temouri et al., 2008). As in previous chapters, the main industry of the MNE obtained from the Fame database was used as proxy.

5. MODEL

As in previous two chapters, the residual of the productivity function, TFP, was used as dependent variable accounting for productivity differences between firms (Temouri et al., 2008). The approach for obtaining this variable is same as in previous two chapters (detailed description in section 4.1. of the fourth chapter). To test specific hypotheses, in the second step we introduce determinants of the TFP estimate. Since testing a full model for all hypotheses would mean introducing the same knowledge creation indicators multiple times, we estimate one model for hypothesis one and two and separate models for hypotheses three and four. The approach follows standard methodology and the models are (Javorcik, 2004; Temouri et al., 2008):

$$\varepsilon_{it} = \beta_0 + \beta_1\varepsilon_{it-1} + \beta_2 IIK_{it} + \beta_3 IIK_{it}^2 + \beta_4 EIK_{it} + \beta_5 EIK_{it}^2 + \beta_6 EI_I + \beta_7 IIK_{it}\, EI_I + \beta_8 IIK_{it}^2 EI_I + \beta_9 IEK_{it}\, EI_I + \beta_{10} IEK_{it}^2 EI_I + \beta_{11} SK_{it} + \beta_{12} Pd_i + \beta_{13}\, C_i + \beta_{14} IA_{it} + \beta_{15} A_{it} + \beta_{16} S_{it} + v_{it} \quad (6.1.)$$

to test hypotheses 6.1. and 6.2.,

$$\varepsilon_{it} = \beta_0 + \beta_1\varepsilon_{it-1} + \beta_2 B_{it} + \beta_3 EI_I + \beta_4 B_{it}\, EI_I + \beta_5 Pd_i + \beta_6\, C_i + \beta_7 IA_{it} + \beta_8 A_{it} + \beta_9 S_{it} + v_{it} \quad (6.2.)$$

for hypothesis 6.3. and

$$\varepsilon_{it} = \beta_0 + \beta_1\varepsilon_{it-1} + \beta_2 Bie_{it} + \beta_3 EI_I + \beta_4 Bie_{it}\, EI_I + \beta_5 Pd_i + \beta_6\, C_i + \beta_7 IA_{it} + \beta_8 A_{it} + \beta_9 S_{it} + v_{it} \quad (6.4.)$$

for hypothesis 6.4.

where ε_{it} is the TFP estimate, IIK_{it} , IIK_{it}^2, IEK_{it} and IEK_{it}^2 refer to international internal and external knowledge creation variables and their squared values, B_{it} refers to the balance between single country and international knowledge, Bie_{it} represents balance between international internal and external knowledge, EI_I is industry level environmental instability, $IIK_{it}\, EI_I$, $IIK_{it}^2 EI_I$, $IEK_{it}\, EI_I$, $IEK_{it}^2 EI_I$, $B_{it}\, EI_I$ and $Bie_{it}\, EI_I$ are the interaction terms using the main knowledge creation independents and environmental instability, SK_{it} is single country knowledge, Pd_i is product diversity, C_i is the number of countries in which the MNE operates, IA_{it} intangible assets, A_{it} signifies age, S_{it} refers to size and v_{it} is the error term, i refers to firm and t to the time period and I to industry. The model also includes industry and time dummies, but for simplicity reasons we do not include these in the expression.

The hypotheses and models test the moderating effect of environmental instability. Moderation is an established and widely used method where the moderator effect is defined

in form of an interaction between a focal independent variable and the factor that specifies the conditions for the effects of the focal independent variable on the dependent variable (Baron and Kenny, 1986). As in previous studies, we interpret moderation as an interaction effect of the instability of the environment and knowledge creation strategies of an organization on performance (Drazin and Van de Ven, 1985).

Firstly the moderating effect of environmental instability on the initial curvilinear relationship between international internal and external knowledge creation and MNE performance is tested to address hypothesis 6.1. and 6.2. Secondly, the moderating effect of environmental instability on the positive relationship between balance of single country and international and internal and external international knowledge creation and performance is analysed, as suggested by hypotheses 6.3. and 6.4.

Since we have a two-way and three-way interaction in particular cases (squared values of international internal and external knowledge creation variables multiplied with the moderator) multicollinearity is a concern and needs to be addressed (Aiken and West, 1991; Baron and Kenny, 1986). For these interaction terms, we apply the residual centering procedure used in prior studies (De Jong et al., 2005; Lance, 1988). Residual centering is a method used to avoid multicollinearity between the interaction term and the variables forming the interaction by using residuals in the main model instead of interaction terms (De Jong et al., 2005). Residuals for each interaction variable were given using the same procedure as in prior literature which consists of regressing the interaction term on its components and obtaining the residuals, which then represent the interaction variable to be used in the main models and in this way solves the potential multicollinearity problem (De Jong et al., 2005).

All three models are estimated using system GMM as in previous two chapters which provides estimates of superior consistency compared to other methods (OLS, RE) and controls for endogeneity and unobservable heterogeneity (Pindado and Requejo, 2012). The applicability of the method is discussed in detail in the fourth chapter.

6. SUMMARY STATISTICS

Table 6.2. presents the descriptive statistics and correlations. The mean values, standard deviations and correlation matrix of particular independent and control variables have been discussed in previous two chapters. The variable introduced in this chapter is environmental instability. Its mean and standard deviation are .075 and .053 respectively. The variable does not show significant association with the main variables, apart from a positive and significant association with internal international knowledge ($p<.05$). The lack of correlation between the

moderator variable and both the predictors and dependents is a desirable condition for moderated effects as it ensures an easier interpretation (Baron and Kenny, 1986).

Table 6.2. Summary (mean and S.D.) and pairwise correlation statistics (* denotes significance level<.05)

		Mean	Standard deviation	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Turnover	1174993	1952274													
2	Capital	758396.5	1597382	.32*												
3	Labour	7564.07	16115.88	.17*	.13*											
4	International patents, internal	.002	.021	- .15*	.01	.24*										
5	International patents, external	.012	.034	- .08*	.01	.29*	.32*									
6	Balance single country/international patents	.363	.373	.18*	.04	-.04	-.17*	-.31*								
7	Balance international internal/external patents	.225	.360	.07*	-.02	-.27*	-.45*	-.96*	.32*							
8	Environmental instability	.075	.053	.04	-.01	.05	.06*	.04	.01	-.03						
9	Single country patents	.341	.461	-.19*	-.05*	.22*	.02	.24*	-.33*	-.22*	-.03					
10	Product diversity	9.73	10.99	.07*	.10*	.50*	.22*	.32*	-.18*	-.31*	-.05*	.22*				
11	Number of countries in which MNE operates	7.91	11.56	- .14*	- .08*	.43*	.24*	.33*	-.22*	-.32*	.11*	.26*	.44*			
12	Intangible Assets	291577.2	1247902	.30*	.40*	.31*	.05*	.11*	.03	-.12*	-.03	.01	.25*	.01		
13	Age	50.53	33.28	.01	.02	- .04	- .07*	- .03	-.01	.03	.01	-.04	-.01	-.16*	-.10	
14	Size (dummy)	.5	.50	.61*	.18*	.19*	- .05*	- .01	.01	.01	.06*	-.05	.09*	.08*	.24*	-.01

7. RESULTS

Table 6.3. below shows the results of the models testing the moderating effect of environmental instability as predicted by the hypotheses in this chapter. The literature suggests that the moderator hypothesis is supported if the interaction term is significant (Baron and Kenny, 1986). The significance in main effects for independents and the moderator is not relevant for testing the moderator hypothesis (Baron and Kenny, 1986). However, the results show a negative and significant direct effect of environmental instability on performance (column 1, 2, 3, 6, Table 6.3.), following prior studies (Lepak et al., 2003).

The first hypothesis (H6.1.) predicted an interaction effect of environmental instability on the U-shaped relationship between international internal knowledge and TFP as the dependent variable. Specifically, the hypothesis suggested that firms operating in more unstable environments will benefit more from higher levels of international internal knowledge. Both the main and squared interaction term are significant (β=-.067, β=.010, $p < 0.01$) (column 2, Table 6.3.). The coefficients show that MNE TFP decreases when moderate levels of internal international knowledge are applied in environments with high levels of instability. Also, MNE TFP increases at higher levels of internal international knowledge in highly unstable environments. Therefore, the results support the hypothesis.

Hypothesis two (H6.2.) predicted an interaction effect of environmental instability on the U-shaped relationship between external international knowledge and TFP as the dependent variable. It suggested that firms operating in more unstable environments will benefit more from higher levels of international external knowledge. Both the main and squared interaction term are significant (β=.023, β=-.005, $p < 0.01$) (column 2, Table 6.3.), however the signs are different compared to internal international knowledge. TFP is expected to increase when moderate levels of international external knowledge are applied in conditions of high instability. However, high levels of international external knowledge are less beneficial for performance in unstable environments. Therefore, the results do not support the hypothesis.

The third (H6.3.) and fourth (H6.4.) hypotheses test the interaction effect of environmental instability on the relationship between balance of single country and international knowledge and TFP and between balance of international internal and external knowledge and TFP. The third hypothesis (H6.3.) suggests that environmental instability positively moderates the relationship between the balance of single country and international knowledge creation and MNE group performance. The interaction term of environmental instability and balance of single country and international knowledge has a negative and significant effect on TFP

(β=.-.003, p <0.05) (column 4, Table 6.3.), which shows that in conditions of high instability in the environment, balancing between single country and international knowledge creation is not a beneficial strategy to pursue and firms should focus more on one particular strategy of knowledge creation. Therefore, the third hypothesis (H6.3.) is not supported.

Hypothesis four (H6.4.) suggests that environmental instability positively moderates the relationship between the balance of international internal and external knowledge creation and MNE group performance. According to the results in column 6 Table 6.3., the interaction term of environmental instability and balance of international internal and external knowledge has a positive and significant effect on TFP (β=.004, p <0.01), which shows that in conditions of high instability in the environment, balancing between internal and external international knowledge creation brings significant performance benefits. Therefore, the hypothesis is confirmed.

There was no significant autocorrelation (AR2 value is insignificant) in the models and the difference-in-Hansen tests of exogeneity of instrument subsets confirmed that instruments are adequate (Roodman, 2009). Also, Wald tests for all independent variables and time and industry dummies were performed to ensure suitability of the independents for the model (Roodman, 2009) and the results (Appendix 12, 13 and 14) substantiate the inclusion of selected variables.

7.1. Robustness checks

As in previous two chapters, we check the reliability of the main results by estimating different measures of performance as the dependent variable and running the models again. Firstly we use MNE turnover (sales) as dependent variable. The results are presented in Table 6.4. below. Following the main results, hypotheses one (H6.1.), two (H6.2.) and four (H6.4.) were confirmed, while hypothesis three (H6.3.) was not confirmed. Furthermore, we investigate the proposed moderating effects of environmental instability on labour productivity as a dependent. The results, presented in Table 6.5., suggest that hypotheses one (H6.1.), two (H6.2.) and four (H6.4.) are confirmed and three (H6.3.) is not confirmed, although on a lower level of significance (p <0.05). Finally, we run the models with operating profit as dependent variable and present the results in Table 6.5. Hypotheses one (H6.1.) and two (H6.2.) are supported as in main results, however the interaction coefficients for testing hypotheses three (H6.3.) and four (H6.4.) are insignificant.

Furthermore, we estimate the models using OLS and random effects panel regression and we check for consistency with the main results. The table in Appendix 15 presents the results.

OLS results follow the main results, while coefficients given by RE models are downward biased as expected.

As mentioned in section 4.2., we check the consistency of the main results by employing a different operationalization method for environmental instability. We interact the main independents with the higher and lower-technology industry dummy as prior studies suggest it as an alternative method to study the instability of the environment when firm level R&D data is not available. We apply the same procedure for testing moderating effects and compare the results. The table in Appendix 16 presents the results. The coefficients largely follow the main results. However, there are some differences. When the higher and lower-technology industries dummy is presented as moderator, the interaction terms incorporating the international internal and external knowledge creation variables (hypotheses 6.1. and 6.2.) have opposite signs compared to the main results. This could indicate caution while generalising the main effect or point to the observation that the two indicators of instability might capture different aspects of the construct and therefore yield different results. However, the results testing hypothesis three (H6.3.) and four (H6.4.) are consistent with the main results.

We can conclude that the main results regarding the moderating effect of environmental instability on the relationship between internal and external international knowledge creation and TFP are fairly robust to different specifications of the dependent variable. Also, the main results regarding the moderating effect of environmental instability on the relationship between balance of single country and international and international internal and external knowledge creation and TFP are fairly robust to other estimation methods, with exception in some models which indicates caution when generalising.

Table 6.3. The moderating effect of environmental instability on the relationship between international internal and external knowledge and TFP, and the relationship between the balance between single country and international and international internal and external knowledge and TFP

	Hypothesis	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dependent variable:		TFP	TFP	TFP	TFP	TFP	TFP
		(1)	(2)	(3)	(4)	(5)	(6)
Independents							
Lagged dependent variable		.915***	.893***	.895***	.899***	.885***	.888***
		(.003)	(.009)	(.007)	(.005)	(.007)	(.004)
International patents, internal		-.017**	-.013				
		(.006)	(.004)				
International patents, internal²		.004***	.002				
		(.001)	(.003)				
International patents, external		-.015***	.032***				
		(.004)	(.003)				
International patents, external²		.004***	-.006**				
		(.008)	(.001)				
Balance single country/international patents				.004**	.004**		
				(.001)	(.001)		
Balance international internal/ external patents						-.001*	.009**
						(.002)	(.002)
Environmental instability		-.020**	-.459**	-.005†	-.004	-.007	-.027*
		(.006)	(.115)	(.013)	(.011)	(.014)	(.010)
Interactions							

International patents, internal x Environmental instability	H6.1.		**-.067****				
			(.016)				
International patents, internal² x Environmental instability	H6.1.		**.010****				
			(.002)				
International patents, external x Environmental instability	H6.2.		**.023****				
			(.003)				
International patents, external² x Environmental instability	H6.2.		**-.005****				
			(.003)				
Balance single country/international patents x Environmental instability	H6.3.				**-.003***		
					(.001)		
Balance international internal/ external patents x Environmental instability	H6.4.						**.004****
							(.001)
Controls							
Single country patents		-.005***	-.011***			-.010*	-.006
		(.001)	(.003)			(.004)	(.004)
Product diversity		.021***	.019**	.030**	.031***	.032***	.034***
		(.002)	(.016)	(.007)	(.006)	(.008)	(.005)
Number of countries in which MNE operates		-.007***	-.012**	-.009*	-.010**	-.011*	-.006
		(.002)	(.004)	(.004)	(.003)	(.005)	(.004)
Intangible Assets		.001*	.006***	.002*	.001	.001	-.001
		(.002)	(.001)	(.001)	(.001)	(.001)	(.001)
Age		-.020***	-.017*	-.020*	-.022**	-.020**	-.025***
		(.006)	(.004)	(.006)	(.006)	(.007)	(.006)

Size (dummy)	.061***	.070***	.074***	.075***	.101***	.096***
	(.003)	(.012)	(.012)	(.010)	(.012)	(.009)
Time (dummy)	Included	Included	Included	Included	Included	Included
Industry (dummy)	Included	Included	Included	Included	Included	Included
(Constant)	12.643***	.230***	1.265***	1.225***	1.474***	1.28***
	(.050)	(.361)	(.106)	(.078)	(.099)	(.074)
AR(2) z-value	-0.53	-1.22	-1.15	-1.16	-1.57	-1.37
Sargan test chi² value	295.83	246.90	250.69	263.31	251.09	267.04
Hansen test chi² value	131.90	104.09	82.40	107.77	102.77	118.89
Number of instruments	122	154	97	106	98	121
F value	633.40	624.11	440.43	655.34	346.61	411.44
Number of observations	1350	1350	1350	1350	1251	1251
Estimation method	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors are in parentheses. Lagged dependent variable, Intangible assets and particular knowledge based indicators were considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets. For testing models 5 and 6 a reduced sample was used, 11 MNEs which did not record any international patents in the period were excluded as it was not possible to estimate the main independents for these MNEs.

Table 6.4. The moderating effect of environmental instability on the relationship between international internal and external knowledge and turnover (sales), and the relationship between the balance between single country and international and international internal and external knowledge and turnover

	Hypothesis	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dependent variable:		Turnover/ Sales	Turnover/ Sales	Turnover/ Sales	Turnover/ Sales	Turnover/ Sales	Turnover/ Sales
		(1)	(2)	(3)	(4)	(5)	(6)
Independents							
Lagged dependent variable		.326***	.244***	.291***	.214***	.172***	.195***
		(.006)	(.005)	(.005)	(.005)	(.005)	(.004)
Total Assets		.002*	.002*	.001	.013*	.008*	.007*
		(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Number of Employees		.212***	.304***	.400***	.418***	.379***	.375***
		(.013)	(.017)	(.020)	(.019)	(.028)	(.015)
International patents, internal		.030	.363*				
		(.028)	(.036)				
International patents, internal²		-.010*	-.082*				
		(.005)	(.007)				
International patents, external		-.433***	-.606**				
		(.012)	(.031)				
International patents, external²		.106***	.148**				
		(.002)	(.007)				
Balance single country/international patents				-.001	.010*		
				(.001)	(.001)		

Balance international internal/ external patents						.004*	.011
						(.002)	(.001)
Environmental instability		-.088***	-.046	-.162**	-.135**	-.151*	-.326***
		(.025)	(.029)	(.058)	(.060)	(.059)	(.036)
Interactions							
International patents, internal x Environmental instability	H6.1.		**-.537****				
			(.071)				
International patents, internal² x Environmental instability	H6.1.		**.081***				
			(.012)				
International patents, external x Environmental instability	H6.2.		**.131***				
			(.025)				
International patents, external² x Environmental instability	H6.2.		**-.028***				
			(.025)				
Balance single country/international patents x Environmental instability	H6.3.				**-.009***		
					(.002)		
Balance international internal/ external patents x Environmental instability	H6.4.						**.033***
							(.002)
Controls							
Single country patents		-.064**	-.076***	-.095***	-.107***		
		(.006)	(.006)	(.006)	(.003)		
Product diversity		-.042*	-.075*	-.227**	-.259**	-.172**	-.202**
		(.017)	(.015)	(.026)	(.037)	(.038)	(.029)

Number of countries	-.197***	-.219***	-.302***	-.313***	-.343***	-.345***
in which MNE operates	(.011)	(.011)	(.017)	(.023)	(.022)	(.015)
Intangible Assets	-.029*	-.026*	-.018*	-.013*	-.025***	-.022***
	(.001)	(.011)	(.001)	(.001)	(.001)	(.001)
Age	-.077***	-.074***	-.073***	-.085***	-.109**	-.102*
	(.017)	(.018)	(.019)	(.021)	(.031)	(.021)
Size (dummy)	.785***	.764***	.518***	.509***	.831***	.755***
	(.020)	(.027)	(.019)	(.036)	(.054)	(.036)
Time (dummy)	Included	Included	Included	Included	Included	Included
Industry (dummy)	Included	Included	Included	Included	Included	Included
(Constant)	1.306**	5.802***	6.118***	7.107***	7.733***	7.177***
	(.217)	(.197)	(.247)	(.333)	(.334)	(.236)
AR(2) z-value	-0.97	-0.95	-0.11	-0.19	-0.96	-1.01
Sargan test chi^2 value	232.35	127.65	436.28	430.17	254.89	279.69
Hansen test chi^2 value	134.91	125.29	132.32	133.34	118.27	126.63
Number of instruments	137	153	144	148	130	147
F value	688.77	804.30	370.12	628.48	380.78	361.32
Number of observations	1350	1350	1350	1350	1251	1251
Estimation method	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors are in parentheses. Lagged dependent variable, Total assets, Number of employees, Intangible Assets and particular knowledge variables are considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets. For testing models in column 2 and 4 a reduced sample was used, 11 MNEs which did not record any international patents in the period were excluded as it was not possible to estimate the main independents for these MNEs.

Table 6.5. The moderating effect of environmental instability on the relationship between international internal and external knowledge and labour productivity and operating profit, and the relationship between the balance between single country and international and international internal and external knowledge and labour productivity and operating profit

	Hypothesis	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Dependent variable:		Labour productivity	Labour productivity	Labour productivity	Labour productivity	Operating Profit	Operating Profit	Operating Profit	Operating Profit
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Independents									
Lag of dependent variable		.590***	.592***	.456***	.598***	.432***	.432***	.427***	.440***
		(.008)	(.018)	(.029)	(.008)	(.005)	(.006)	(.015)	(.007)
Total Assets /Total Assets per Employee		.014***	.014***	.018***	.014***	.040***	.041***	.0415***	.115***
		(.001)	(.001)	(.002)	(.001)	(.008)	(.006)	(.010)	(.008)
Number of Employees						.306**	.456***	1.410***	.801***
						(.117)	(.129)	(.230)	(.139)
International patents, internal		-.305***	-.251***			-.473***	-.585***		
		(.050)	(.064)			(.049)	(.068)		
International patents, internal^2		.048**	.033**			.515***	.300***		
		(.007)	(.009)			(.051)	(.061)		
International patents, external		-.129***	-.133***			.240***	.209***		
		(.018)	(.024)			(.010)	(.023)		
International patents, external^2		.029***	.031***			-.246***	-.192***		
		(.004)	(.006)			(.013)	(.022)		

Balance single country/ international patents				.021*** (.005)				-.022 (.026)	
Balance international internal/ external patents					.015** (.002)				.011 (.021)
Environmental instability		.013 (.056)	.017 (.058)	-.035 (.124)	-.059 (.076)	-1.009*** (.187)	-.960*** (.118)	-1.959*** (.517)	.436 (.285)
Interactions									
International patents, internal x Environmental instability	H6.1.		**-.298**** (.085)				**-.746***** (.344)		
International patents, internal² x Environmental instability	H6.1.		**.044**** (.014)				**.247***** (.065)		
International patents, external x Environmental instability	H6.2.		**.070*** (.034)				**.403***** (.106)		
International patents, external² x Environmental instability	H6.2.		**-.016*** (.007)				**-.073***** (.024)		
Balance single country/international patents x Environmental instability	H6.3.			**-.007*** **(.003)**				.049 (.036)	

Balance international internal/ external patents x Environmental instability	H6.4.			**.005*** **(.003)**				.117 (.029)
Controls								
Single country patents	-.052** (.012)	-.055** (.015)		-.065*** (.010)	.020 (.029)	.027 (.038)		.060 (.028)
Product diversity	-.198** (.028)	-.186** (.035)	-.227*** (.029)	-.240*** (.027)	-.038 (.131)	-.038 (.150)	-.359 (.256)	-.005 (.173)
Number of countries in which MNE operates	-.211*** (.013)	-.189*** (.022)	-.241*** (.016)	-.233*** (.014)	-.166 (.086)	-.157 (.094)	-.666** (.122)	-.410** (.072)
Intangible Assets	-.033*** (.032)	-.039*** (.002)	-.030*** (.002)	-.031*** (.002)	-.022* (.009)	-.018 (.012)	-.119** (.020)	-.127** (.010)
Age	-.068* (.024)	-.071* (.030)	-.095** (.023)	-.088** (.026)	.176* (.084)	.219* (.101)	.268* (.131)	.262* (.010)
Size (dummy)	.546*** (.019)	.494*** (.044)	.551*** (.019)	.564*** (.019)	.207† (.123)	-.043 (.155)	.138 (.244)	.280* (.108)
Time (dummy)	Included	Included	Included	Included	Included	Included	Included	Included
Industry (dummy)	Included	Included	Included	Included	Included	Included	Included	Included
(Constant)	-.095 (-0.48)	.315 (.572)	2.536*** (.299)	2.660*** (.356)	-5.166*** (1.163)	-6.878*** (1.157)	-15.02*** (1.987)	-3.789* (1.627)
AR(2) z-value	0.24	0.07	0.59	0.03	0.93	0.87	0.98	1.05
Sargan test	353.07	336.23	360.08	352.73	208.26	206.44	115.43	132.71
Hansen test	115.17	100.65	110.07	112.92	130.95	126.82	87.29	121.87

Number of instruments	110	120	120	121	222	226	112	137
F value	603.72	370.20	709.05	504.66	641.61	892.97	133.22	147.68
Number of observations	1350	1350	1350	1251	1350	1350	1350	1251
Estimation method	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors are in parentheses. Lagged dependent variable, Total assets, Number of employees, Intangible Assets and particular knowledge variables are considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets. For testing models in column 4 and 8 a reduced sample was used, 11 MNEs which did not record any international patents in the period were excluded as it was not possible to estimate the main independents for these MNEs.

8. DISCUSSION AND CONCLUSION

Prior literature emphasised that MNEs and their subsidiaries operate in specific environments which condition their operations by pressuring them to adapt to the environment's unique characteristics such as instability or degree of change (Birkinshaw and Hood, 1998; Child, 1972; Dess and Beard, 1984; Ghoshal and Bartlett, 1990; Kogut and Zander, 1992; Kogut and Zander, 1993; Lewin et al., 1999; Simerly and Li, 2000). In fact, a robust strand of innovation and management literature argues that in order to perform well, MNEs need to match their knowledge strategies depending on whether the environment is more or less unstable (Jansen et al., 2006; Levinthal and March, 1993; Li and Atuahene-Gima, 2001; Lichtenthaler, 2009; Luo and Peng, 1999).

Despite the substantial research interest, studies have not yet fully examined the effect of environmental instability on the MNE's locational and organisational knowledge creation choices. Specifically, the literature does not offer sufficient evidence regarding which locational and organisational knowledge creation choices of the MNE are most beneficial in which environments. What we do not know from prior studies is how performance outcomes of knowledge creation of specific locational and organisational origins differ according to the environment, limiting our understanding of how MNEs align their knowledge creation choices to the environment in order to achieve higher performance.

8.1. Theoretical and practical implications

The findings in this chapter add to the rich literature regarding the role of the context for the knowledge and performance relationship. We show in detail how environmental instability moderates the relationship between different international knowledge creation strategies, with some interesting findings.

Firstly, we show that it is beneficial in highly unstable environments to engage extensively in international internal knowledge creation as it provides a richer knowledge base and builds knowledge creation capabilities. This finding follows prior literature which showed that internal knowledge and capabilities are crucial under environmental instability (Argyres and Silverman, 2004; Arora et al., 2014; Sorenson, 2003; Thornhill, 2006) Also, a study showed that firms whose knowledge is internally interdependent learn more effectively in unstable environments (Sorenson, 2003). Because knowledge advantages of firms that do not promote extensive collaboration among different units erode quickly when changes happen, they will experience losses (Sorenson, 2003).

In contrast, the results suggest that when instability is high, firms should moderately apply external international knowledge. This finding challenges prior literature which argues that external knowledge may be particularly valuable in unstable contexts. In fact, prior studies suggest that the firm is highly dependent on the adoption of new external technologies under environmental instability (Kogut and Zander, 1992; Kogut and Zander, 1993; Uotila et al., 2009). A relevant explanation for the effect found in this study might be that a high reliance on international knowledge created with external partners operating in different countries may, based on the costs and risks these strategies bring, add to the complexity firms suffer from by operating in unstable environments. Also, prior studies focus on the role of external knowledge in general, whereas it might be the case that a high dependence on, for instance, external knowledge sourcing in unstable environments might bring different effects than a high dependence on external knowledge creation, international in particular.

Apart from moderating the value of exact levels of different international knowledge strategies, the instability of the environment influences the value of the ways in which different knowledge creation strategies are distributed within the MNE. The evidence in this chapter shows that different combinations of knowledge creation strategies are suitable for different environments and adds to other studies that examined in which situations firms should combine different knowledge strategies (Gupta et al., 2006)

Specifically, the results suggest that under high instability MNEs should not opt for a balance between single country and international knowledge creation strategies. This finding confirms other related studies which emphasise that balanced strategies of knowledge may not be logical and attainable in all contexts (Gupta et al., 2006; Jansen et al., 2006; Uotila et al., 2009). Although our findings do not specify which of the two strategies the firm should focus on when the environment is unstable, insights regarding the additivity of specific international knowledge creation strategies discussed above may give a direction. The firm might be better off if it devoted more resources and efforts to international internal than single country knowledge creation because of the significance of this strategy. Ultimately, firms operating in unstable environments will be faced with a trade-off between single country and international knowledge creation.

Furthermore, we provide evidence regarding how firms should combine different international knowledge creation strategies under different conditions. The results show that in conditions of high instability, firms should pursue both internal and external strategies of international knowledge creation and try to achieve a balance between the two. These findings are similar to findings regarding the impact of the context on the balance between existing and new knowledge in the firm (Gupta et al., 2006; March, 1991).

This result might seem at first in contrast to the finding that international external knowledge is not beneficial under instability (discussed above). However, previous chapter showed that internal and external international knowledge creation strategies when combined are complementary and may reinforce each other. Although international external knowledge itself might not be beneficial, because of this complementarity effect a balance between the two international knowledge strategies might be crucial if the environment is unstable.

This analysis also has managerial implications as it shows that knowledge creation strategy should be aligned with the context when firms are deciding which strategies of knowledge creation to pursue in order to build their performance. The results suggest that managers in both stable and unstable environments should be aware of the knowledge creation choices they make. Even if they engage in different international knowledge creation strategies to a similar extent as other firms, the value of these choices will depend on the environment. Similarly, two firms that combine knowledge creation strategies in a similar way will experience similar performance only if operating in similar contexts.

9. LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH

In order to further specify the impact of the environment, other constructs and operationalisations of environmental instability may be used to compare the effects. For instance, many recent studies focus on analysing the effects of industry clockspeed, which specifically captures the rate of product and process obsolescence (Mudambi and Swift, 2011; Nadkarni and Narayanan, 2007; Patel et al., 2014). More recent literature also analyses instability by focusing on its technological dimension and distinguishes environments based on rate of technological change specifically (Jaworski and Kohli, 1993; Klevorick et al., 1995; Li and Atuahene-Gima, 2001; Lichtenthaler, 2009; Uotila et al., 2009). Examining the effects of other types of environmental instability on the main relationships would give a more detailed overview of the importance of this specific characteristic of the firm's environment.

Furthermore, other characteristics of the context such as culture, knowledge and competitive environment can potentially influence the performance and international knowledge creation relationship (Argote et al., 2003; Drazin and Van de Ven, 1985). For instance, a study showed the importance of universities and research centres involved in basic R&D as an important contextual variable which may influence the value of different knowledge strategies because these represent valuable information sources for the knowledge creation process of the firm (Cassiman and Veugelers, 2006).

Apart from the context attributes, what may also be important is the source of instability in the environment. A recent study showed that instability can be firm or industry specific and

the source can be a major factor in determining how firms will organise their operations (Beckman et al., 2004). To shield themselves from firm specific instability, the firm will pursue external new knowledge from other fields and industries more (Beckman et al., 2004). If the uncertainty is within an industry, the firms belonging to the same industry will strengthen their internal relationships as a strategy to jointly overcome the changes (Beckman et al., 2004). Therefore, it would be useful to relate MNE knowledge creation strategies to the specific source of instability.

An interesting research direction that follows is to consider the dynamics of firm's knowledge creation choices under different environmental conditions. Is the distribution of knowledge creation strategies within the MNE stable or is it a response to constant changes in the context and the source of the changes? Recent studies showed that dynamics in the technological features of knowledge in the firm is indeed a response to the constantly changing environments (Beckman et al., 2004; Mudambi and Swift, 2011). In fact, environments, rather than being stable or unstable, may be characterized by periods of relative stability interspersed with periods of radical change, which means that the knowledge creation strategies and combinations of strategies may constantly shift as a response (Mudambi and Swift, 2011; Mudambi and Swift, 2014). Considering these possibilities in relation to the firm's international knowledge creation choices would significantly enrich the study.

CHAPTER VII

CONCLUSION

1. INTRODUCTION

This study set out to explore the concept and value of knowledge creation strategies with different locational and organisational origins within the multinational enterprise. The importance of creating new valuable knowledge is strongly rooted in the literature as one of the main factors of firm survival and growth (Grant, 1996; Kogut and Zander, 1992; Kogut and Zander, 1993).

Knowledge creation strategy refers to the different strategic choices regarding the locational and organisational origins of knowledge creation (Berry, 2014; He and Wong, 2004). MNEs may create knowledge using single country or international strategies (locational origin), individually or in collaboration with various internal and external partners such as units, universities or research centres (organisational origin) which may operate in different countries (Arora et al., 2014; Berry, 2014; Kogut and Zander, 1992; Kogut and Zander, 1993; Van de Vrande, 2013).

A growing share of knowledge has been created using international strategies, which refer to knowledge that is created between at least two knowledge co-creators from at least two different countries (Berry, 2014; Patel et al., 2014; Van de Vrande, 2013). Despite its growing importance, many of its aspects still remain largely unexplored such as the significance of its different strategies for the MNE (Foss and Pedersen, 2004; Kotabe et al., 2007; Phene and Almeida, 2008). What we specifically do not know is the value of international knowledge creation strategies depending on whether the co-creators come from within the same MNE (international internal knowledge creation) or from outside the MNE (international external knowledge creation). Furthermore, we do not know whether the MNE allocates more or less of its knowledge creation resources to international internal and external knowledge creation strategies compared to other strategies and how these choices impact performance. Finally, theory suggests that all knowledge choices need to be aligned with the environment in which the MNE operates (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993) which then raises the question of which international knowledge creation strategies are most suitable for which environments.

Therefore, based on the inconclusiveness of evidence regarding international knowledge creation strategies in particular, this study sought to answer the following research questions:

1. *How do different international knowledge creation strategies affect MNE performance?*
2. *Do MNEs which combine different international knowledge creation strategies in a more balanced way achieve higher performance compared to MNEs which prioritise between them?*
3. *How does the environment in which the MNE operates affect the relationship between international knowledge creation strategies and MNE performance?*

To answer these research questions and develop specific hypotheses, this study relies primarily on knowledge of the firm and subsidiary evolution theory supplemented by interrelated theories such as extended resource based view and portfolio theory. We take into account a specific form of knowledge creation, technical knowledge, which we measure as patents granted. The analysis is based on a sample of 46,712 patents granted to 150 UK-headquartered manufacturing sector MNEs and their 5,352 first level subsidiaries during the 2003 to 2012 period.

2. EMPIRICAL FINDINGS

The hypotheses, methodology and empirical results were presented in detail in the fourth, fifth and sixth chapter of this thesis. This section briefly synthesises the findings.

The first research question focused on uncovering the ways in which different international knowledge creation strategies may affect MNE performance. Specifically, we explored the relationship between international internal and external knowledge creation strategies and MNE group performance. Based on the arguments given by knowledge of the firm and subsidiary evolution theory, we hypothesised that international internal knowledge creation may have a U-shaped relationship with MNE performance. Due to the higher costs related to the need to simplify the new knowledge accessed through this strategy, low and moderate levels of international internal knowledge creation will have a negative effect on MNE performance (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). However, at higher levels of international internal knowledge creation, the costs will be reduced as the knowledge transfer and sharing between units will be more effective (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). The results confirmed this hypothesis.

Regarding international external knowledge creation, we also hypothesised a U-shaped relationship with MNE performance. Based on the theoretical insights we expect that MNEs, when engaging in low and moderate levels of international external knowledge creation, will experience higher costs due to a higher commitment of resources needed to establish the

relationships that enable these strategies and costs related to processing the new information (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). However, at higher levels of international external knowledge creation, MNEs will be able to build on the richness of new knowledge available and the higher capabilities for new knowledge creation, which have been significantly upgraded as an outcome of engaging in these strategies (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). The results confirmed this hypothesis. Therefore, this study answered the first research question by providing evidence that international internal and external knowledge creation strategies have a U-shaped relationship with MNE performance.

The second research question focused on exploring the value of the specific ways in which MNEs combine different international knowledge creation strategies in the overall MNE knowledge strategy. MNEs can either focus on just one knowledge creation strategy or they can opt for a combination of different strategies. In order to answer the research question, we hypothesised that a simultaneous and balanced combination of both single country and international knowledge creation will enable the MNE to effectively leverage the set of technological opportunities it has access to and the risk of imitation, which will build MNE performance (Kogut and Zander, 1992; Kogut and Zander, 1993). The results support the hypothesis. By testing this hypothesis, the study explains the significance of combining international knowledge creation in general in the overall MNE knowledge strategy.

Additionally, we suggested that MNEs that combine international internal and external knowledge creation also in a balanced way are able to create new knowledge more efficiently based on higher transferability of the new knowledge accessed (Kogut and Zander, 1992; Kogut and Zander, 1993). The findings support the hypothesis. Therefore, this study answered the second research question by providing evidence that balancing both internal and external international knowledge creation rather than prioritising between them is the most beneficial way in which MNEs can combine different international knowledge creation strategies.

The aim of the third research question is to explore the effect of the environment in which MNEs operate on the relationships mentioned above. Following the theory, we hypothesised that environmental instability, as one of the most important characteristics of the environment, moderates the U-shaped relationship between international internal and external knowledge creation and MNE performance. Specifically, we argue that high levels of international internal and external knowledge creation are specifically crucial in highly unstable environments as they help build an extensive knowledge base, which makes the firm's knowledge creation models more flexible and builds the firm's internal capability to recognise and pursue new opportunities (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). The empirical evidence supports the arguments in case of international

internal knowledge, but does not in the case of international external knowledge. In other words, MNE performance increases in highly unstable environments when higher levels of internal international knowledge creation are adopted by the MNE. In contrast, high levels of international external knowledge creation are less beneficial for MNE performance in highly unstable environments.

Additionally, we explore the moderating effect of environmental instability on the way in which MNEs combine different knowledge creation strategies. Based on the theory, we hypothesise that a balanced combination of single country and international knowledge creation strategies will be particularly beneficial in unstable environments, as overspecialisation may lead to a weaker knowledge base and capabilities (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). Similarly, we suggest that a balanced combination of both international internal and external knowledge creation will be crucial for survival in unstable environments, as employing both strategies simultaneously may help the MNE to be more flexible and efficient while creating knowledge (Birkinshaw and Hood, 1998; Kogut and Zander, 1992; Kogut and Zander, 1993). The evidence confirmed only the latter hypothesis. In conditions of high instability, a balance between single country and international knowledge creation is not beneficial. However, a balance between internal and external international knowledge creation brings significant performance benefits in unstable environments. Therefore, we answer the third research question by showing that firms need to align their knowledge creation choices and the ways in which they combine different international knowledge creation strategies to the environment.

3. THEORETICAL CONTRIBUTIONS

Managing knowledge creation in MNEs is a topic that has received significant attention in the literature with recent studies recording a growing trend of international knowledge as a specific knowledge creation strategy that the firms increasingly engage in (Berry, 2014; Patel et al., 2014; Van de Vrande, 2013).

However, studies exploring the phenomenon of international knowledge offered inconsistent views regarding its value. While some authors conceptualise international knowledge as the ideal strategy through which the firm can access diverse knowledge and significantly enrich its internal knowledge base (Birkinshaw and Hood, 1998; Chung and Yeaple, 2008; Kogut and Zander, 1992; Kogut and Zander, 1993; Phene and Almeida, 2008), others suggest that international knowledge may be the least attractive strategy because it is highly complex and involves a variety of costs and challenges (Kogut and Zander, 1992; Kogut and Zander, 1993; Leiponen and Helfat, 2010; March, 1991). Apart from these conflicting arguments, studies

also observed that the literature has not yet fully examined all of the features of international knowledge, which, as the research progresses, may reconcile these views (Foss and Pedersen, 2004; Kotabe et al., 2007; Phene and Almeida, 2008).

The results of this study give additional insight into the specific value of international knowledge creation and its different types as well as how to combine these complex strategies in order to benefit from them. By doing this, we contribute to discussion regarding the significance of global knowledge and attempt to resolve at least partially the aforementioned inconsistencies (Berry, 2014; Kogut and Zander, 1992; Kogut and Zander, 1993; Patel et al., 2014; Van de Vrande, 2013).

Firstly, we give an overview of the possible locational and organisational origins of MNE knowledge creation, as acknowledged and examined separately by prior studies. Based on the locational origins, MNEs can create knowledge either using single country or international strategies (Berry, 2014). We focus specifically on international strategies and identify different types within that grouping. According to the organisational origins, international knowledge can be either internal or external and we examine their related values which, to the best of our knowledge, has not been analysed in this context.

We hypothesise that both internal and external international knowledge creation can be accompanied by benefits and costs depending on how extensively MNEs apply these strategies. As mentioned in previous section, we show that MNEs need to surpass a certain threshold of engaging in both internal and external international knowledge creation for the positive performance effects of a richer knowledge base and stronger knowledge creation capabilities to materialise. In other words, the results show that both internal and external international knowledge creation have a U-shaped relationship with MNE performance. Lower levels of these strategies will require a significant devotion of resources in order to build the relationships these strategies are based on and to implement the diverse knowledge accessed across the whole MNE. However, as MNEs commit more intensely to these strategies, these costs are reduced and benefits materialise.

These findings reinforce prior studies which argued that firms should collaborate with internal and external partners operating in different countries and adopt more open models of knowledge creation (Alnuaimi et al., 2012; Chesbrough and Crowther, 2006; Frost and Zhou, 2005; Lahiri, 2010; Laursen and Salter, 2006). By specifying the value of international internal and external knowledge creation strategies, we confirm the role that both internal and external knowledge creation play for firm performance, emphasised by knowledge of the firm theory and competitive advantage of interconnected firms (Kogut and Zander, 1992; Kogut and

Zander, 1993; Lavie, 2006). The theories recognised that knowledge can be created individually as well as in interconnected environments, but did not examine the specific performance effects of different international knowledge creation strategies. Furthermore, by examining the effects on MNE level we were able to show how these strategies affect the whole group, which differs from studies explaining the effects on subsidiary level (Birkinshaw and Hood, 1998). Finally, we show why and to what extent international internal and external knowledge creation can be a critical firm resource, which is still not fully researched (Teece, 2007).

At the same time, the findings challenge prior studies which showed that firms benefit from moderate, but not high levels of international knowledge (Berchicci, 2013; Grimpe and Kaiser, 2010; Kotabe et al., 2007; Laursen and Salter, 2006). However, prior studies analysed international knowledge as a source rather than a knowledge creation strategy. Therefore, our findings suggest that the value of international knowledge creation is different and very specific compared to other forms of integrating international knowledge into the firm.

Secondly, following prior similar studies, we acknowledge that international knowledge creation is a strategy which firms can combine with other strategies in order to build a portfolio of different ways in which knowledge is created (Vassolo et al., 2004). We show that performance differences can be explained by the ways in which firms combine international knowledge creation strategies in the MNE (Vassolo et al., 2004). As mentioned in the previous section, we show that MNEs should combine both single country and international knowledge creation strategies in a balanced way in order to achieve higher performance. In this way, we offer additional insight into the tension between local and international knowledge in the firm (Patel et al., 2014).

Also, we offer evidence suggesting that both internal and external international knowledge creation strategies should be represented rather equally in a balanced way within the international knowledge creation part of the overall MNE knowledge strategy. These findings confirm the theoretical and empirical evidence given by prior studies looking at how firms combine different knowledge strategies and extend them by showing how international knowledge creation strategies specifically fit in the MNE's overall knowledge creation strategy, which has not been addressed fully (Bogers and West, 2012; Cassiman and Veugelers, 2006; Grimpe and Sofka, 2009; Kogut and Zander, 1992; Kogut and Zander, 1993; Lewin et al., 2011; Lokshin et al., 2008; March, 1991; Nicholls‐Nixon and Woo, 2003; Patel et al., 2014). These studies showed that internal and external knowledge are complementary and the positive performance effects of one strategy increase if the firm engages more intensely in the other (Cassiman and Veugelers, 2006; Grimpe and Kaiser, 2010; Lokshin et

al., 2008). However, the studies did not explain how to allocate resources between the two in the international part of the knowledge creation strategy, which is a contribution specific to this thesis. Finally, we show that the way in which firms combine international knowledge may constitute idiosyncratic situations which act as a foundation for higher performance, adding to other studies which looked at international knowledge as a potential source of advantage for a firm (Fang et al., 2007; Kogut and Zander, 1992; Kogut and Zander, 1993; Teece, 2007).

Thirdly, this study offers evidence on how environmental instability moderates the relationship between different international knowledge creation strategies and how they are combined within the MNE, as discussed in the previous section. In this way we add to the rich literature regarding the role of the context for the knowledge and performance relationship as prior studies showed that a firm's knowledge strategy should be aligned with the specifics of the environment (Child, 1972; Dess and Beard, 1984; Ghoshal and Bartlett, 1990; Jansen et al., 2006; Lewin et al., 1999; Li and Atuahene-Gima, 2001; Lichtenthaler, 2009; Luo and Peng, 1999).

Although these studies examined the influence of the environment from various aspects of the firm's knowledge strategy, they did not offer sufficient evidence regarding which locational and organisational knowledge creation choices of the MNE are most beneficial in which environments. We address this gap by showing that high levels of international internal knowledge creation are valuable in highly unstable environments, following studies which showed that internal knowledge and internal knowledge collaborations in general are valuable when the context is unstable (Argyres and Silverman, 2004; Arora et al., 2014; Sorenson, 2003; Thornhill, 2006).

However, the results showing the value of international external knowledge creation under high instability challenge prior studies to an extent. We find that high levels of international external knowledge are less beneficial when the environment is highly unstable, whereas prior studies suggested that the firm, when faced with instability, relies more on new external knowledge (Kogut and Zander, 1992; Uotila et al., 2009). This contrasting finding may be related to the specific knowledge creation strategy examined, international external knowledge, whereas prior studies looked at external knowledge in general. Future studies should examine these differences in more detail in order to confirm the unique properties of international external knowledge.

Furthermore, the evidence in this thesis shows that different combinations of knowledge creation strategies are suitable for environments characterised with different levels of instability. The results suggest that under high instability MNEs should focus their efforts and

resources on either single country or international knowledge creation, rather than on both equally, as in other studies which emphasise that balanced knowledge strategies are not beneficial in specific contexts (Gupta et al., 2006; Jansen et al., 2006; Uotila et al., 2009).

In contrast, when looking at the distribution of different international knowledge creation strategies, we found evidence that in conditions of high instability, firms should pursue both internal and external international knowledge creation in a balanced way, similar to findings by other studies which examined how firms combine existing and new technologies in unstable contexts (Gupta et al., 2006; March, 1991). Also, it may be the case that the complementarity effect between internal and external knowledge found in prior studies is more pronounced in unstable environments in case of international internal and external knowledge creation (Cassiman and Veugelers, 2006; Grimpe and Kaiser, 2010; Lokshin et al., 2008).

4. PRACTICAL IMPLICATIONS

This thesis offers practical insights for managers who make choices regarding the locational and organisational origins of knowledge creation in the MNE. Firstly, this thesis shows that around one third of all patents are created using international strategies, as in recent studies (Berry, 2014). Therefore, managers are increasingly adopting internal and external international knowledge creation as a strategy to create knowledge.

Furthermore, the findings suggest that international internal and external knowledge creation may be the most suitable strategy for accessing and benefiting from high levels of knowledge diversity. Managers should promote these two international knowledge creation strategies as a tool to upgrade the existing knowledge base, capabilities and performance of the whole group.

Extant literature has highlighted a tension between different knowledge strategies which compete for limited resources designated for knowledge creation (Birkinshaw and Hood, 1998; Gibson and Birkinshaw, 2004; Tushman and O'Reilly III, 1996). Due to this internal competition for resource allocation, MNEs need to make difficult choices regarding how to efficiently distribute scarce inputs between different knowledge creation strategies (Bogers and West, 2012; March, 1991). The empirical evidence confirms that different combinations of knowledge creation strategies may build or restrict the performance of the whole MNE.

Specifically, we show that firms need to combine international knowledge and single country strategies in a balanced way, as well as international internal and external knowledge strategies as the most efficient way to allocate resources which will lead to higher MNE performance.

A final managerial implication of this study is that it shows knowledge creation strategy choices and how firms combine them should be aligned with the environment in which the firm operates. Two firms applying and combining international knowledge creation strategies in a similar fashion will experience performance differences depending on the instability of the environment.

5. LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH

This research has several limitations. Firstly, we assume that all patents used as indicators of knowledge creation are of same value, which prior studies showed is not the case (March, 1991; Singh, 2008; Van de Vrande, 2013). Particular patents are of higher value as they represent significant breakthroughs in the respective technological field, while some patents may represent incremental advances and are less valuable (Griliches, 1998b). The performance effects of knowledge creation strategies may therefore be defined by the value of the patent rather than the strategy used to create it. Also, particular international knowledge creation strategies may result with knowledge of higher value compared to other strategies. Comparing the value of patents would enable us to draw more specific conclusions regarding the value of knowledge creation strategies used to create it, but this was not possible due to time limitations. However, it represents an interesting extension to the study.

Secondly, we assume that knowledge created using particular knowledge creation strategies has similar characteristics. However, specific attributes of knowledge such as its tacitness matter (Kogut and Zander, 1992; Kogut and Zander, 1993; Yamin and Otto, 2004) and hence the features of particular patents created using international knowledge creation strategies may also shape their performance effect.

Thirdly, we do not consider technological origins of knowledge creation and assume that the strategies examined result with knowledge that has similar technological features. However, prior literature has also conceptualised knowledge creation based on the type of technology it creates, whether it is explorative or exploitative (Ahuja and Katila, 2001; Benner and Tushman, 2003; Hoang and Rothaermel, 2010; March, 1991; Uotila et al., 2009). Exploration in knowledge creation means that knowledge creation involves sourcing external knowledge outside the MNE, beyond the main technological domain (March, 1991). Exploitation, on the other hand, refers to knowledge created by focusing on refinement of existing technologies, competences and paradigms already present in the firm (March, 1991). Yet, since this characterisation explores the degree of external knowledge, some studies mention it as being closely related to the organisational boundary and perhaps the locational also (March, 1991). In this way, exploitation would most likely happen within the MNE, whereas exploration

would involve knowledge outside the MNE. Also, with regards to location, exploitation type of knowledge would be most probably created in a single country environment, whereas different locations would probably include exploratory processes. In this view, by analysing the locational and organisational origins simultaneously, the conclusions obtained may give an indication of possible effects given by looking at the technological features of knowledge creation strategies. Future research should try and reconcile the three characterisations in order to analyse the performance effect of different knowledge creation strategies in more detail.

Furthermore, this study only considers patents as evidence of MNE knowledge creation and excludes all other ways in which MNEs create new knowledge. However, not all innovations are patented and not all innovations are patentable (Griliches, 1998b). Therefore, future studies should extend the knowledge creation measures used in this study and include other possible forms in order to analyse whether the performance effects are comparable for all other ways in which MNE knowledge is created.

In addition, we assume that all knowledge creation strategies of a specific type are similar. However, there may be differences between, for instance, internal international knowledge creation strategies depending on the characteristics of the units that collaborate in these strategies. For instance, we do not consider whether an MNE creates knowledge between same units or whether different units participate in each internal international knowledge creation project. Knowledge heterogeneity accessed by engaging in internal international knowledge creation strategies which include the same units may be limited compared to the diversity of that could be accessed by internal international knowledge created by different units each time. If the internal international knowledge is created in a structurally diverse group where members, by their different organizational affiliations or positions represent a unique source of knowledge, the value of such strategies may be higher (Cummings, 2004).

Moreover, other features of the units may affect the value of knowledge such as the unit's position in the MNE network or their knowledge capabilities. Units which have a more central network position or interact more with other units may also engage in international internal knowledge creation more and derive more value from it because of their superior position compared to other units (Ghoshal and Bartlett, 1990; Tsai, 2001). Also, collaborations between units with stronger learning and combinative capabilities may result with knowledge of higher value (Birkinshaw and Hood, 1998; Cohen and Levinthal, 1990). Taking into account the units which collaborate on knowledge creation and their features would scrutinise the value of knowledge creation strategies further.

Similarly, it would be interesting to examine which partners specifically add most value when the MNE engages in international external knowledge creation. Features such as partner type

(competitors, suppliers, customers, universities and other), their level of know-how or the industry they operate in may significantly affect the value of a particular external international knowledge creation project (Belderbos et al., 2004; De Clercq and Dimov, 2008; Dushnitsky and Shaver, 2009; Hoang and Rothaermel, 2005; Mowery et al., 1996). Due to national differences in innovation infrastructure and the environment for innovation (Furman et al., 2002), the value of knowledge may be related to the country the partners operate in. Apart from partner specific factors, we also do not consider the exact form of knowledge creation collaboration which can be, for instance, an alliance, joint venture or informal R&D collaboration, which was recently found as a significant determinant of the value of a firm's knowledge creation strategy (Van de Vrande, 2013).

Although we examine the value of combining different knowledge creation strategies in the MNE, we do not test specifically the extent to which their characteristics overlap which, as argued by portfolio theory, is a significant determinant of their combined value (Vassolo et al., 2004). For instance, if the knowledge that is accessed through a combination of strategies is similar to an extent, the performance effect might be limited and the whole portfolio of strategies would be sub-additive (Vassolo et al., 2004). In this view, combining knowledge creation strategies in the MNE may be less important than the extent to which the strategies are equivalent.

The measures used in this study have their limitations. For instance, future studies could test the hypotheses using other indicators of MNE performance as a dependent variable such as innovation performance or Tobin's Q type measures. Also, applying other constructs of environmental instability can be used to study its moderating effect on the knowledge and performance relationship. Environment specific factors such as the rate of technological change (Jaworski and Kohli, 1993; Klevorick et al., 1995; Li and Atuahene-Gima, 2001; Lichtenthaler, 2009; Uotila et al., 2009) or industry clockspeed, which captures product and process obsolescence (Mudambi and Swift, 2011; Nadkarni and Narayanan, 2007; Patel et al., 2014) can be used to for a more detailed analysis of the environment specific effect. Studies also argue that features of the environment such as culture, competition and knowledge creation environment such as the existence of universities and research centres involved in R&D can determine the knowledge and performance relationship (Argote et al., 2003; Drazin and Van de Ven, 1985). However, the limited time and data availability did not permit for inclusion of these different measures.

Finally, this study tests the value of different knowledge creation strategies and combinations of strategies on the group level, but it would be useful to analyse the effects of these strategies on, for instance, the team and individual project level (Hoang and Rothaermel, 2010; Raisch

et al., 2009). Also, the conclusions are limited by the sample and time period chosen. Further studies may wish to test the assumptions using a sample of MNEs headquartered in different countries and a combined sample of MNEs from different countries or country groupings and compare the effects.

REFERENCES

Adams, J.D. and Jaffe, A.B. 1996. Bounding the effects of R&D: An investigation using matched establishment-firm data. *Rand Journal of Economics.* **27**(4), pp.700-721.

Ahuja, G. and Katila, R. 2001. Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. *Strategic Management Journal.* **22**(3), pp.197-220.

Ahuja, G. and Katila, R. 2004. Where do resources come from? The role of idiosyncratic situations. *Strategic Management Journal.* **25**(8-9), pp.887-907.

Aiken, L.S. and West, S.G. 1991. *Multiple regression: Testing and interpreting interactions.* London: Sage Publications, Inc.

Alcácer, J. and Zhao, M. 2012. Local R&D strategies and multilocation firms: The role of internal linkages. *Management Science.* **58**(4), pp.734-753.

Almeida, P. 1996. Knowledge sourcing by foreign multinationals: patent citation analysis in the US semiconductor industry. *Strategic Management Journal.* **17**, pp.155-165.

Almeida, P. et al. 2002. Are firms superior to alliances and markets? An empirical test of cross-border knowledge building. *Organization Science.* **13**(2), pp.147-161.

Alnuaimi, T. et al. 2012. Not with my own: long-term effects of cross-country collaboration on subsidiary innovation in emerging economies versus advanced economies. *Journal of Economic Geography.* **12**(5), pp.943-968.

Ambos, B. 2005. Foreign direct investment in industrial research and development: A study of German MNCs. *Research policy.* **34**(4), pp.395-410.

Andriopoulos, C. and Lewis, M.W. 2009. Exploitation-exploration tensions and organizational ambidexterity: Managing paradoxes of innovation. *Organization Science.* **20**(4), pp.696-717.

Appleyard, M.M. 1996. How does knowledge flow? Interfirm patterns in the semiconductor industry. *Strategic management journal.* **17**(2), pp.137-154.

Argote, L. and Ingram, P. 2000. Knowledge transfer: A basis for competitive advantage in firms. *Organizational behavior and human decision processes.* **82**(1), pp.150-169.

Argote, L. et al. 2003. Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management science.* **49**(4), pp.571-582.

Argyres, N.S. and Silverman, B.S. 2004. R&D, organization structure, and the development of corporate technological knowledge. *Strategic Management Journal.* **25**(8-9), pp.929-958.

Arnold, J.M. and Hussinger, K. 2005. Export behavior and firm productivity in German manufacturing: a firm-level analysis. *Review of World Economics.* **141**(2), pp.219-243.

Arora, A. et al. 2014. Make, buy, organize: The interplay between research, external knowledge, and firm structure. *Strategic Management Journal.* **35**(3), pp.317-337.

Arora, A. et al. 2001. Markets for technology and their implications for corporate strategy. *Industrial and corporate change.* **10**(2), pp.419-451.

Artz, K.W. et al. 2003. Firm performance: A longitudinal study of R&D, patents and product innovation. In: *Academy of Management Proceedings*: Academy of Management, **2003**(1), pp.B1-B6.

Artz, K.W. et al. 2010. A longitudinal study of the impact of R&D, patents, and product innovation on firm performance. *Journal of Product Innovation Management.* **27**(5), pp.725-740.

Audretsch, D.B. and Feldman, M.P. 1996. R&D spillovers and the geography of innovation and production. *The American Economic Review.* **86**(3), pp.630-640.

Barney, J.B. 1991. Firm resources and sustained competitive advantage. *Journal of Management.* **17**(1), pp.99-120.

Barney, J.B. 2001. Resource-based theories of competitive advantage: A ten-year retrospective on the resource-based view. *Journal of Management.* **27**(6), pp.643-650.

Baron, R.M. and Kenny, D.A. 1986. The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of personality and social psychology.* **51**(6), pp.1173-1182.

Beckman, C.M. et al. 2004. Friends or strangers? Firm-specific uncertainty, market uncertainty, and network partner selection. *Organization science.* **15**(3), pp.259-275.

Belderbos, R. et al. 2004. Cooperative R&D and firm performance. *Research Policy.* **33**(10), pp.1477-1492.

Belderbos, R. et al. 2010. Technological Activities and Their Impact on the Financial Performance of the Firm: Exploitation and Exploration within and between Firms. *Journal of Product Innovation Management.* **27**(6), pp.869-882.

Belderbos, R. et al. 2008. Strategic R&D location by multinational firms: spillovers, technology sourcing, and competition. *Journal of Economics & Management Strategy.* **17**(3), pp.759-779.

Belderbos, R. et al. 2013. International and domestic technology transfers and productivity growth: firm level evidence. *Industrial and Corporate Change.* **22**(1), pp.1-32.

Bell, G. G. 2005. Clusters, networks, and firm innovativeness. *Strategic management journal*, **26**(3), pp.287-295.

Benner, M.J. and Tushman, M.L. 2003. Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of management review.* **28**(2), pp.238-256.

Benton, T. and Craib, I. 2010. *Philosophy of Social Science: The Philosophical Foundations of Social Thought (2nd ed.)*. New York: Palgrave Macmillan.

Berchicci, L. 2013. Towards an open R&D system: internal R&D investment, external knowledge acquisition and innovative performance. *Research Policy.* **42**(1), pp.117-127.

Berry, H. 2014. Global integration and innovation: Multicountry knowledge generation within MNCs. *Strategic Management Journal.* **35**(6), pp.869-890.

Birkinshaw, J. and Hood, N. 1998. Multinational subsidiary evolution: capability and charter change in foreign-owned subsidiary companies. *Academy of management review.* **23**(4), pp.773-795.

Blomström, M. and Persson, H. 1983. Foreign investment and spillover efficiency in an underdeveloped economy: evidence from the Mexican manufacturing industry. *World development.* **11**(6), pp.493-501.

Bloom, N. and Van Reenen, J. 2002. Patents, real options and firm performance. *The Economic Journal.* **112**(478), pp.97-116.

Blundell, R. and Bond, S. 2000. GMM estimation with persistent panel data: an application to production functions. *Econometric reviews.* **19**(3), pp.321-340.

Bogers, M. and West, J. 2012. Managing distributed innovation: strategic utilization of open and user innovation. *Creativity and innovation management.* **21**(1), pp.61-75.

Boumgarden, P. et al. 2012. Sailing into the wind: Exploring the relationships among ambidexterity, vacillation, and organizational performance. *Strategic Management Journal.* **33**(6), pp.587-610.

Brouthers, K.D. 2002. Institutional, cultural and transaction cost influences on entry mode choice and performance. *Journal of International Business Studies.* **33**(2), pp.203-221.

Buckley, P.J. 2009. The impact of the global factory on economic development. *Journal of World Business.* **44**(2), pp.131-143.

Buckley, P.J. and Carter, M.J. 1999. Managing cross-border complementary knowledge: conceptual developments in the business process approach to knowledge management in multinational firms. *International Studies of Management & Organization.* **29**(1), pp.80-104.

Burt, R.S. 2004. Structural holes and good ideas. *American journal of sociology.* **110**(2), pp.349-399.

Cameron, A.C. and Trivedi, P.K. 2009. *Microeconometrics using stata.* Stata Press College Station, TX.

Cantwell, J. and Piscitello, L. 2002. The location of technological activities of MNCs in European regions: The role of spillovers and local competencies. *Journal of International Management.* **8**(1), pp.69-96.

Cassiman, B. et al. 2010. Organizing links with science: Cooperate or contract?: A project-level analysis. *Research Policy.* **39**(7), pp.882-892.

Cassiman, B. and Veugelers, R. 2006. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science.* **52**(1), pp.68-82.

Chesbrough, H. and Crowther, A.K. 2006. Beyond high tech: early adopters of open innovation in other industries. *R&d Management.* **36**(3), pp.229-236.

Chesbrough, H.W. 2006. The era of open innovation. *Managing innovation and change.* **127**(3), pp.34-41.

Child, J. 1972. Organizational structure, environment and performance: the role of strategic choice. *Sociology.* **6**(1), pp.1-22.

Chung, W. and Yeaple, S. 2008. International knowledge sourcing: Evidence from US firms expanding abroad. *Strategic Management Journal.* **29**(11), pp.1207-1224.

Cohen, W.M. and Levinthal, D.A. 1990. Absorptive capacity: a new perspective on learning and innovation. *Administrative science quarterly.* **35**(1), pp.128-152.

Cui, A.S. et al. 2005. The influence of competitive intensity and market dynamism on knowledge management capabilities of multinational corporation subsidiaries. *Journal of International Marketing.* **13**(3), pp.32-53.

Cui, L. and Jiang, F. 2012. State ownership effect on firms' FDI ownership decisions under institutional pressure: a study of Chinese outward-investing firms. *Journal of International Business Studies.* **43**(3), pp.264-284.

Cummings, J.N. 2004. Work groups, structural diversity, and knowledge sharing in a global organization. *Management science.* **50**(3), pp.352-364.

De Clercq, D. and Dimov, D. 2008. Internal knowledge development and external knowledge access in venture capital investment performance. *Journal of Management Studies.* **45**(3), pp.585-612.

De Jong, A. et al. 2005. Antecedents and consequences of group potency: A study of self-managing service teams. *Management Science.* **51**(11), pp.1610-1625.

Deeds, D.L. and Decarolis, D.M. 1999. The impact of stocks and flows of organizational knowledge on firm performance: an empirical investigation of the biotechnology industry. *Strategic management journal.* **20**(10), pp.953-968.

Delios, A. and Beamish, P.W. 2001. Survival and profitability: The roles of experience and intangible assets in foreign subsidiary performance. *Academy of Management journal.* **44**(5), pp.1028-1038.

Dess, G.G. and Beard, D.W. 1984. Dimensions of organizational task environments. *Administrative science quarterly.* **29**(1), pp.52-73.

Di Minin, A. and Bianchi, M. 2011. Safe nests in global nets: Internationalization and appropriability of R&D in wireless telecom. *Journal of International Business Studies.* **42**(7), pp.910-934.

Drazin, R. and Van de Ven, A.H. 1985. Alternative forms of fit in contingency theory. *Administrative science quarterly.* pp.514-539.

Driffield, N. et al. 2010. The multinational enterprise as a source of international knowledge flows: Direct evidence from Italy. *Journal of International Business Studies.* **41**(2), pp.350-359.

Duncan, R.B. 1972. Characteristics of organizational environments and perceived environmental uncertainty. *Administrative science quarterly.* pp.313-327.

Dunning, J.H. and Lundan, S.M. 2010. The institutional origins of dynamic capabilities in multinational enterprises. *Industrial and corporate change.* **19**(4), pp.1225-1246.

Dushnitsky, G. and Shaver, J.M. 2009. Limitations to interorganizational knowledge acquisition: the paradox of corporate venture capital. *Strategic Management Journal.* **30**(10), pp.1045-1064.

Eisenhardt, K.M. and Martin, J.A. 2000. Dynamic capabilities: what are they? *Strategic management journal.* **21**(10-11), pp.1105-1121.

Faems, D. et al. 2010. Technology Alliance Portfolios and Financial Performance: Value-Enhancing and Cost-Increasing Effects of Open Innovation. *Journal of Product Innovation Management.* **27**(6), pp.785-796.

Fang, Y. et al. 2007. International diversification, subsidiary performance, and the mobility of knowledge resources. *Strategic Management Journal.* **28**(10), pp.1053-1064.

Feinberg, S.E. and Gupta, A.K. 2004. Knowledge spillovers and the assignment of R&D responsibilities to foreign subsidiaries. *Strategic Management Journal.* **25**(8-9), pp.823-845.

Florida, R. 1997. The globalization of R&D: Results of a survey of foreign-affiliated R&D laboratories in the USA. *Research policy.* **26**(1), pp.85-103.

Foss, N.J. et al. 2013. The role of external knowledge sources and organizational design in the process of opportunity exploitation. *Strategic Management Journal.* **34**(12), pp.1453-1471.

Foss, N.J. and Pedersen, T. 2004. Organizing knowledge processes in the multinational corporation: an introduction. *Journal of International Business Studies.* **35**(5), pp.340-349.

Frost, T.S. 2001. The geographic sources of foreign subsidiaries' innovations. *Strategic Management Journal*. **22**(2), pp.101-123.

Frost, T.S. et al. 2002. Centers of excellence in multinational corporations. *Strategic Management Journal*. **23**(11), pp.997-1018.

Frost, T.S. and Zhou, C. 2005. R&D co-practice and 'reverse'knowledge integration in multinational firms. *Journal of International Business Studies.* **36**(6), pp.676-687.

Furman, J.L. et al. 2002. The determinants of national innovative capacity. *Research Policy*. **31**(6), pp.899-933.

Geerts, A. et al. 2010. Achieving a balance between exploration and exploitation in service firms: a longitudinal study. In: *Academy of Management Proceedings*: Academy of Management, **2010**(1), pp.1-6.

Ghoshal, S. and Bartlett, C.A. 1990. The multinational corporation as an interorganizational network. *Academy of management review*. **15**(4), pp.603-625.

Gibson, C.B. and Birkinshaw, J. 2004. The antecedents, consequences, and mediating role of organizational ambidexterity. *Academy of management Journal*. **47**(2), pp.209-226.

Gómez, J. and Maícas, J.P. 2011. Do switching costs mediate the relationship between entry timing and performance? *Strategic Management Journal*. **32**(12), pp.1251-1269.

Grant, R.M. ed. 1991. The resource-based theory of competitive advantage: implications for strategy formulation. *Knowledge and strategy*. 3-23.

Grant, R.M. 1996. Toward a knowledge-based theory of the firm. *Strategic management journal*. **17**(S2), pp.109-122.

Griliches, Z. 1979. Issues in assessing the contribution of research and development to productivity growth. *The Bell Journal of Economics.* pp.92-116.

Griliches, Z. 1992. The search for R&D spillovers. *The Scandinavian Journal of Economics.* **94**, pp.29-47.

Griliches, Z. 1998a. Issues in assessing the contribution of research and development to productivity growth. *R&D and Productivity: The Econometric Evidence.* University of Chicago Press, pp.17-45.

Griliches, Z. 1998b. Patent statistics as economic indicators: a survey. *R&D and productivity: the econometric evidence.* University of Chicago Press, pp.287-343.

Grimpe, C. and Hussinger, K. 2014. Resource complementarity and value capture in firm acquisitions: The role of intellectual property rights. *Strategic Management Journal*. **35**(12), pp.1762-1780.

Grimpe, C. and Kaiser, U. 2010. Balancing internal and external knowledge acquisition: the gains and pains from R&D outsourcing. *Journal of Management Studies.* **47**(8), pp.1483-1509.

Grimpe, C. and Sofka, W. 2009. Search patterns and absorptive capacity: Low-and high-technology sectors in European countries. *Research Policy*. **38**(3), pp.495-506.

Gupta, A.K. and Govindarajan, V. 2000. Knowledge flows within multinational corporations. *Strategic Management Journal.* **21**(4), pp.473-496.

Gupta, A.K. et al. 2006. The interplay between exploration and exploitation. *Academy of Management Journal*. **49**(4), pp.693-706.

Haleblian, J. and Finkelstein, S. 1993. Top management team size, CEO dominance, and firm performance: The moderating roles of environmental turbulence and discretion. *Academy of Management Journal*. **36**(4), pp.844-863.

Hall, B.H. 1993. The stock market's valuation of R&D investment during the 1980's. *The American Economic Review*. pp.259-264.

Hall, B.H. and Mairesse, J. 1995. Exploring the relationship between R&D and productivity in French manufacturing firms. *Journal of econometrics.* **65**(1), pp.263-293.

Hall, B.H. et al. 2007. The market value of patents and R&D: evidence from European firms. In: *Academy of Management Proceedings*: Academy of Management. **2007**(1), pp.1-6.

Hansen, G.S. and Wernerfelt, B. 1989. Determinants of firm performance: The relative importance of economic and organizational factors. *Strategic management journal.* **10**(5), pp.399-411.

Hanson, G.H. et al. 2005. Vertical production networks in multinational firms. *Review of Economics and statistics.* **87**(4), pp.664-678.

Harris, M. et al. 1982. Asymmetric information, incentives and intrafirm resource allocation. *Management Science.* **28**(6), pp.604-620.

He, Z.-L. and Wong, P.-K. 2004. Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis. *Organization science.* **15**(4), pp.481-494.

Hillier, D. et al. 2011. The impact of country-level corporate governance on research and development. *Journal of International Business Studies.* **42**(1), pp.76-98.

Hoang, H. and Rothaermel, F.T. 2005. The effect of general and partner-specific alliance experience on joint R&D project performance. *Academy of Management Journal.* **48**(2), pp.332-345.

Hoang, H. and Rothaermel, F.T. 2010. Leveraging internal and external experience: exploration, exploitation, and R&D project performance. *Strategic Management Journal.* **31**(7), pp.734-758.

Jaffe, A.B. 1989. Real effects of academic research. *The American Economic Review.* **79**(5), pp.957-970.

Jansen, J.J. et al. 2006. Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators. *Management science.* **52**(11), pp.1661-1674.

Jansen, J.J. et al. 2009. Structural differentiation and ambidexterity: The mediating role of integration mechanisms. *Organization Science* **20**(4), pp.797-811.

Javorcik, B.S. 2004. Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. *American economic review.* **94**(3), pp.605-627.

Jaworski, B.J. and Kohli, A.K. 1993. Market orientation: antecedents and consequences. *The Journal of marketing.* **57**(3), pp.53-70.

Jensen, R. and Szulanski, G. 2004. Stickiness and the adaptation of organizational practices in cross-border knowledge transfers. *Journal of International Business Studies.* **35**(6), pp.508-523.

Kafouros, M.I. et al. 2012. The effects of global knowledge reservoirs on the productivity of multinational enterprises: The role of international depth and breadth. *Research Policy.* **41**(5), pp.848-861.

Kafouros, M.I. et al. 2008. The role of internationalization in explaining innovation performance. *Technovation.* **28**(1-2), pp.63-74.

Katila, R. and Ahuja, G. 2002. Something old, something new: A longitudinal study of search behavior and new product introduction. *Academy of management journal.* **45**(6), pp.1183-1194.

Keats, B.W. and Hitt, M.A. 1988. A causal model of linkages among environmental dimensions, macro organizational characteristics, and performance. *Academy of management journal.* **31**(3), pp.570-598.

Kirner, E. et al. 2009. Innovation paths and the innovation performance of low-technology firms—An empirical analysis of German industry. *Research Policy.* **38**(3), pp.447-458.

Klevorick, A.K. et al. 1995. On the sources and significance of interindustry differences in technological opportunities. *Research policy.* **24**(2), pp.185-205.

Kogut, B. and Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization science.* **3**(3), pp.383-397.

Kogut, B. and Zander, U. 1993. Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies.* **24**(4), pp.625-645.

Kotabe, M. et al. 2007. Determinants of cross-national knowledge transfer and its effect on firm innovation. *Journal of International Business Studies.* **38**(2), pp.259-282.

Kurokawa, S. et al. 2007. Global R&D activities of Japanese MNCs in the US: a triangulation approach. *Research Policy.* **36**(1), pp.3-36.

Lahiri, N. 2010. Geographic Distribution of R&D Activity: How Does it Affect Innovation Quality? *The Academy of Management Journal.* **53**(5), pp.1194-1209.

Lance, C.E. 1988. Residual centering, exploratory and confirmatory moderator analysis, and decomposition of effects in path models containing interactions. *Applied Psychological Measurement.* **12**(2), pp.163-175.

Laursen, K. and Salter, A. 2006. Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. *Strategic management journal.* **27**(2), pp.131-150.

Lavie, D. 2006. The competitive advantage of interconnected firms: An extension of the resource-based view. *The Academy of Management Review archive.* **31**(3), pp.638-658.

Leiponen, A. and Helfat, C.E. 2010. Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal.* **31**(2), pp.224-236.

Lepak, D.P. et al. 2003. Employment flexibility and firm performance: Examining the interaction effects of employment mode, environmental dynamism, and technological intensity. *Journal of Management.* **29**(5), pp.681-703.

Levinsohn, J. and Petrin, A. 2003. Estimating production functions using inputs to control for unobservables. *The Review of Economic Studies.* **70**(2), pp.317-341.

Levinthal, D.A. and March, J.G. 1993. The myopia of learning. *Strategic management journal.* **14**(2), pp.95-112.

Lewin, A.Y. et al. 1999. The coevolution of new organizational forms. *Organization Science.* **10**(5), pp.535-550.

Lewin, A.Y. et al. 2011. Microfoundations of internal and external absorptive capacity routines. *Organization Science.* **22**(1), pp.81-98.

Li, H. and Atuahene-Gima, K. 2001. Product innovation strategy and the performance of new technology ventures in China. *Academy of Management Journal.* **44**(6), pp.1123-1134.

Lichtenthaler, U. 2009. Absorptive capacity, environmental turbulence, and the complementarity of organizational learning processes. *Academy of Management Journal.* **52**(4), pp.822-846.

Liebeskind, J.P. 1996. Knowledge, strategy, and the theory of the firm. *Strategic management journal.* **17**(Winter Special Issue), pp.93-107.

Liu, X. et al. 2009. Do local manufacturing firms benefit from transactional linkages with multinational enterprises in China. *Journal of International Business Studies.* **40**(7), pp.1113-1130.

Lokshin, B. et al. 2008. The Productivity Effects of Internal and External R&D: Evidence from a Dynamic Panel Data Model. *Oxford Bulletin of Economics and Statistics.* **70**(3), pp.399-413.

Lu, J.W. and Beamish, P.W. 2004. International diversification and firm performance: The S-curve hypothesis. *The Academy of Management Journal.* **47**(4), pp.598-609.

Luo, Y. and Peng, M.W. 1999. Learning to compete in a transition economy: Experience, environment, and performance. *Journal of International Business Studies.* **30**(2), pp.269-295.

Lyles, M.A. and Salk, J.E. 1996. Knowledge acquisition from foreign parents in international joint ventures: An empirical examination in the Hungarian context. *Journal of international business studies.* **27**(5), pp.877-903.

Makino, S. and Delios, A. 1996. Local knowledge transfer and performance: implications for alliance formation in Asia. *Journal of International Business Studies.* **27**(5), pp.905-927.

Mansfield, E. and Lee, J.-Y. 1996. The modern university: contributor to industrial innovation and recipient of industrial R&D support. *Research policy.* **25**(7), pp.1047-1058.

March, J.G. 1991. Exploration and exploitation in organizational learning. *Organization science.* **2**(1), pp.71-87.

Markusen, J.R. 2004. *Multinational firms and the theory of international trade.* The MIT Press.

Martin, X. and Salomon, R. 2003. Knowledge transfer capacity and its implications for the theory of the multinational corporation. *Journal of International Business Studies.* **34**(4), pp.356-373.

McGrath, R.G. 1997. A real options logic for initiating technology positioning investments. *Academy of Management Review.* **22**(4), pp.974-996.

Mesquita, L.F. et al. 2008. Comparing the resource-based and relational views: Knowledge transfer and spillover in vertical alliances. *Strategic Management Journal.* **29**(9), pp.913-941.

Miller, D. and Friesen, P.H. 1983. Strategy-making and environment: the third link. *Strategic management journal.* **4**(3), pp.221-235.

Mowery, D.C. et al. 1996. Strategic alliances and interfirm knowledge transfer. *Strategic management journal.* **17**(2), pp.77-91.

Mudambi, R. and Swift, T. 2011. Leveraging knowledge and competencies across space: the next frontier in international business. *Journal of International Management.* **17**(3), pp.186-189.

Mudambi, R. and Swift, T. 2014. Knowing when to leap: Transitioning between exploitative and explorative R&D. *Strategic Management Journal.* **35**(1), pp.126-145.

Murray, J.Y. et al. 1995. Strategic and financial performance implications of global sourcing strategy: A contingency analysis. *Journal of International Business Studies.* **26**(1), pp.181-202.

Nadkarni, S. and Narayanan, V.K. 2007. Strategic schemas, strategic flexibility, and firm performance: the moderating role of industry clockspeed. *Strategic management journal.* **28**(3), pp.243-270.

Narula, R. and Hagedoorn, J. 1999. Innovating through strategic alliances: moving towards international partnerships and contractual agreements. *Technovation.* **19**(5), pp.283-294.

Nelson, R.R. 1961. Uncertainty, learning, and the economics of parallel research and development efforts. *The Review of Economics and Statistics.* **43**(4), pp.351-364.

Nicholls-Nixon, C.L. and Woo, C.Y. 2003. Technology sourcing and output of established firms in a regime of encompassing technological change. *Strategic Management Journal.* **24**(7), pp.651-666.

Nieto, M.J. and Rodríguez, A. 2011. Offshoring of R&D: Looking abroad to improve innovation performance. *Journal of International Business Studies.* **42**(3), pp.345-361.

Nieto, M.J. and Santamaria, L. 2007. The importance of diverse collaborative networks for the novelty of product innovation. *Technovation.* **27**(6), pp.367-377.

Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. *Organization science.* **5**(1), pp.14-37.

Noorderhaven, N. and Harzing, A.-W. 2009. Knowledge-sharing and social interaction within MNEs. *Journal of International Business Studies.* **40**(5), pp.719-741.

O'Brien, R. M. 2007. A caution regarding rules of thumb for variance inflation factors. *Quality & Quantity*, **41**(5), 673-690.

OECD. 2011. *Classification of manufacturing industries into categories based on R&D intensities.* [Online]. Available from: www.oecd.org/sti/ind/48350231.pdf

OECD. 2012. *OECD Science, technology and industry outlook 2012.* [Online]. Available from: http://www.oecd.org/unitedkingdom/sti-outlook-2012-united-kingdom.pdf

Office for National Statistics 2007. *UK Standard Industrial Classification of Economic Activities 2007 (UK SIC 2007).* [Online]. Available from: http://www.ons.gov.uk/ons/guide-method/classifications/current-standard-classifications/standard-industrial-classification/index.html

Olley, S. and Pakes, A. 1996. Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms. *Econometrica.* **64**(6), pp.1263-1297.

Pakes, A. and Griliches, Z. 1984. Patents and R&D at the firm level: a first look. *R & D, patents, and productivity.* University of Chicago Press, pp.55-72.

Patel, P.C. et al. 2014. Beating competitors to international markets: The value of geographically balanced networks for innovation. *Strategic Management Journal.* **35**(5), pp.691-711.

Pearce, R.D. 1999. Decentralised R&D and strategic competitiveness: globalised approaches to generation and use of technology in multinational enterprises (MNEs). *Research Policy.* **28**(2), pp.157-178.

Peteraf, M.A. 1993. The cornerstones of competitive advantage: A resource-based view. *Strategic management journal.* **14**(3), pp.179-191.

Phene, A. and Almeida, P. 2008. Innovation in multinational subsidiaries: The role of knowledge assimilation and subsidiary capabilities. *Journal of International Business Studies.* **39**(5), pp.901-919.

Pindado, J. and Requejo, I. eds. 2012. Panel data: a methodology for model specification and testing. *Finance volume of Wiley Encyclopedia of Management*

Popper, K. 1959. *The Logic of Scientific Discovery.* London: Hutchinson.

Raisch, S. et al. 2009. Organizational ambidexterity: Balancing exploitation and exploration for sustained performance. *Organization Science.* **20**(4), pp.685-695.

Reitzig, M. and Wagner, S. 2010. The hidden costs of outsourcing: evidence from patent data. *Strategic Management Journal.* **31**(11), pp.1183-1201.

Richard, P.J. et al. 2009. Measuring organizational performance: Towards methodological best practice. *Journal of management.* **35**(3), pp.718-804.

Rigby, D. and Zook, C. 2002. Open-market innovation. *Harvard business review.* **80**(10), pp.80-93.

Roodman, D. 2009. How to do xtabond2: An introduction to difference and system GMM in Stata. *Stata Journal.* **9**(1), p86.

Rothaermel, F.T. and Alexandre, M.T. 2009. Ambidexterity in technology sourcing: The moderating role of absorptive capacity. *Organization Science.* **20**(4), pp.759-780.

Salomon, R. and Jin, B. 2010. Do leading or lagging firms learn more from exporting? *Strategic Management Journal.* **31**(10), pp.1088-1113.

Santamaría, L. et al. 2009. Beyond formal R&D: Taking advantage of other sources of innovation in low-and medium-technology industries. *Research Policy.* **38**(3), pp.507-517.

Sargent, T.C. and Rodriguez, E.R. 2001. *Labour or total factor productivity: Do we need to choose?* Department of Finance, Economic and Fiscal Policy Branch.

Scherer, F.M. 1982. Inter-industry technology flows and productivity growth. *The Review of Economics and Statistics.* **64**(4), pp.627-634.

Simerly, R.L. and Li, M. 2000. Environmental dynamism, capital structure and performance: a theoretical integration and an empirical test. *Strategic Management Journal.* **21**(1), pp.31-49.

Singh, J. 2008. Distributed R&D, cross-regional knowledge integration and quality of innovative output. *Research Policy.* **37**(1), pp.77-96.

Snell, S.A. 1996. The strategic use of integrated manufacturing: an empirical examination. *Strategic management journal.* **17**(6), pp.459-480.

Sørensen, J.B. and Stuart, T.E. 2000. Aging, obsolescence, and organizational innovation. *Administrative science quarterly.* **45**(1), pp.81-112.

Sorenson, O. 2003. Interdependence and Adaptability: Organizational Learning and the Long–Term Effect of Integration. *Management Science.* **49**(4), pp.446-463.

Spencer, J.W. 2003. Firms' knowledge-sharing strategies in the global innovation system: empirical evidence from the flat panel display industry. *Strategic Management Journal.* **24**(3), pp.217-233.

Stettner, U. et al. 2014. The Interplay Between Exploration and Exploitation in SMEs. *Exploration and Exploitation in Early Stage Ventures and SMEs (Technology,*

Innovation, Entrepreneurship and Competitive Strategy, Volume 14) Emerald Group Publishing Limited. **14**, pp.3-13.

Stettner, U. and Lavie, D. 2014. Ambidexterity under scrutiny: Exploration and exploitation via internal organization, alliances, and acquisitions. *Strategic management journal.* **35**(13), pp.1903-1929.

Stuermer, M. et al. 2009. Extending private-collective innovation: a case study. *R&d Management.* **39**(2), pp.170-191.

Subramaniam, M. 2006. Integrating Cross-Border Knowledge for Transnational New Product Development. *Journal of Product Innovation Management.* **23**(6), pp.541-555.

Subramaniam, M. and Venkatraman, N. 2001. Determinants of transnational new product development capability: Testing the influence of transferring and deploying tacit overseas knowledge. *Strategic Management Journal.* **22**(4), pp.359-378.

Szulanski, G. 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic management journal.* **17**, pp.27-43.

Tallman, S. and Li, J. 1996. Effects of international diversity and product diversity on the performance of multinational firms. *Academy of Management Journal.* **39**(1), pp.179-196.

Tanriverdi, H. and Venkatraman, N. 2005. Knowledge relatedness and the performance of multibusiness firms. *Strategic Management Journal.* **26**(2), pp.97-119.

Teece, D.J. 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic management journal.* **28**(13), pp.1319-1350.

Teece, D.J. et al. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal.* **18**(7), pp.509-533.

Temouri, Y. et al. 2008. Analysis of productivity differences among foreign and domestic firms: evidence from Germany. *Review of World Economics.* **144**(1), pp.32-54.

Tether, B.S. and Tajar, A. 2008. Beyond industry–university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base. *Research Policy.* **37**(6), pp.1079-1095.

Thornhill, S. 2006. Knowledge, innovation and firm performance in high-and low-technology regimes. *Journal of Business Venturing.* **21**(5), pp.687-703.

Treasury, H. 2014. *GDP deflators: September 2014 (Quaterly National Accounts).* [Online]. Available from: https://www.gov.uk/government/statistics/gdp-deflators-at-market-prices-and-money-gdp-september-2014-quarterly-national-accounts

Tsai, W. 2001. Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. *Academy of Management Journal.* **44**(5), pp.996-1004.

Tushman, M.L. and O'Reilly III, C.A. 1996. Ambidextrous organizations: managing evolutionary and revolutionary change. *California management review.* **38**(4), pp.8-30

UNCTAD. 2014a. *World Investment Report 2014.* [Online]. Available from: http://unctad.org/en/pages/publicationwebflyer.aspx?publicationid=937

UNCTAD. 2014b. *World Investment Report 2014: Annex Tables* [Online]. Available from: http://unctad.org/en/pages/DIAE/World%20Investment%20Report/Annex-Tables.aspx

Uotila, J. et al. 2009. Exploration, exploitation, and financial performance: analysis of S&P 500 corporations. *Strategic Management Journal.* **30**(2), pp.221-231.

Van de Ven, A.H. 1986. Central problems in the management of innovation. *Management science.* **32**(5), pp.590-607.

Van de Vrande, V. 2013. Balancing your technology-sourcing portfolio: How sourcing mode diversity enhances innovative performance. *Strategic Management Journal.* **34**(5).

Vanhaverbeke, W. et al. 2002. External technology sourcing through alliances or acquisitions: An analysis of the application-specific integrated circuits industry. *Organization Science.* **13**(6), pp.714-733.

Vassolo, R.S. et al. 2004. Non-additivity in portfolios of exploration activities: A real options based analysis of equity alliances in biotechnology. *Strategic Management Journal.* **25**(11), pp.1045-1061.

Venkatraman, N. 1989. The concept of fit in strategy research: toward verbal and statistical correspondence. *Academy of management review.* **14**(3), pp.423-444.

Venkatraman, N. 1990. Performance implications of strategic coalignment: a methodological perspective. *Journal of Management Studies.* **27**(1), pp.19-41.

Venkatraman, N. and Prescott, J.E. 1990. Environment-strategy coalignment: An empirical test of its performance implications. *Strategic Management Journal.* **11**(1), pp.1-23.

Veugelers, R. 1997. Internal R & D expenditures and external technology sourcing. *Research policy.* **26**(3), pp.303-315.

Wagner, S. et al. 2013. Overcoming localization of knowledge–the role of professional service firms. *Strategic Management Journal.* **35**(11), pp.1671-1688.

Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal.* **5**(2), pp.171-180.

West, J. and Bogers, M. 2013. Leveraging external sources of innovation: a review of research on open innovation. *Journal of Product Innovation Management.* **31**(4).

Wooldridge, J.M. 2009. On estimating firm-level production functions using proxy variables to control for unobservables. *Economics Letters.* **104**(3), pp.112-114.

Yamin, M. and Otto, J. 2004. Patterns of knowledge flows and MNE innovative performance. *Journal of International Management.* **10**(2), pp.239-258.

Yang, Q. et al. 2008. Conventional and Reverse Knowledge Flows in Multinational Corporations. *Journal of Management.* **34**(5), pp.882-902.

Yasar, M. et al. 2008. Production function estimation in Stata using the Olley and Pakes method. *Stata Journal.* **8**(2), p221.

Zahra, S.A. 1996. Technology strategy and financial performance: Examining the moderating role of the firm's competitive environment. *Journal of Business venturing.* **11**(3), pp.189-219.

Zahra, S.A. and Bogner, W.C. 2000. Technology strategy and software new ventures' performance: Exploring the moderating effect of the competitive environment. *Journal of business venturing.* **15**(2), pp.135-173.

LIST OF ABBREVIATIONS

Abbreviation	Meaning	
EPO	European Patent Office	70
FDI	Foreign direct investment	9
FE	Fixed effects	84
GDP	Gross Domestic Product	15
IB	International business	10
IPR	Intellectual property rights	34
MNE	Multinational enterprise	2
OECD	Organisation for Economic Co-operation and Development	15
PLC	Public limited company	15
RBV	Resource-based view	24
RE	Random effects	84
R&D	Research and development	11
TFP	Total factor productivity	74
UK	United Kingdom	4
UNCTAD	The United Nations Conference on Trade and Development	15
US	United States	15

APPENDIX

APPENDIX 1

List of raw data variables and corresponding data sources

No	Variable	Source
1	Operating revenue/ Turnover/ Sales	FAME
2	Total Assets	FAME
3	Number of employees	FAME
4	International knowledge creation	EPO
5	Single country knowledge creation	EPO
6	International knowledge creation, internal	EPO
7	International knowledge creation, external	EPO
10	Number of industries in which the MNE operates	FAME
11	Number of countries in which the MNE operates	FAME
12	Number of knowledge creating units	EPO/ FAME
13	Intangible Assets	FAME
14	Firm age	FAME
15	Years of operation	FAME

APPENDIX 2

List of companies in the sample and their main financial and organisational features

No	Company name	Operating Revenue 2012 (000 GBP)	Number of employees 2012	Number of operating countries	Number of subsidiaries (Level 1)
1.	Vodafone Group PLC	44,445,000	91,272	45	466
2.	Glaxosmithkline PLC	26,431,000	98,681	52	139
3.	Astrazeneca PLC	17,209,000	53,500	17	31
4.	BAE Systems PLC	16,620,000	84,000	38	472
5.	Sabmiller PLC	15,239,000	70,486	44	100
6.	Johnson Matthey PLC	10,729,000	10,995	22	50
7.	Reckitt Benckiser Group PLC	9,567,000	35,900	65	289
8.	Wittington Investments Ltd	12,350,000	107,046	3	42
9.	Jaguar Land Rover Ltd	7,214,300	10,013	8	17
10.	Land Rover	6,956,800	6,759	3	4
11.	GKN PLC	6,510,000	40,335	38	130
12.	Vodafone Ltd	5,364,200	7,245	4	8
13.	BAE Systems (Operations) Ltd	4,932,000	19,052	2	8
14.	Kerry Group PLC	4,889,890	24,182	33	128
15.	Gallaher Ltd	4,740,000	1,583	2	6
16.	Tata Steel UK Ltd	4,384,000	18,303	5	45
17.	Cookson Group	4,369,897	16,128	11	45
18.	Eli Lilly and Company	3,980,201	1,289	2	11
19.	IBM United Kingdom Ltd	3,974,300	16,075	2	30
20.	Sony Europe Ltd	3,829,974	4,593	7	11
21.	Boparan Holdings Ltd	3,669,269	14,968	2	10
22.	General Motors UK Ltd	3,508,500	2,793	2	30
23.	Airbus Operations Ltd	3,198,000	8,514	2	6
24.	Smiths Group PLC	3,030,100	23,200	10	259
25.	J.C.B. Service	2,716,100	8,359	4	23
26.	Smith & Nephew PLC	2,545,000	10,477	32	44
27.	Aggreko PLC	2,498,290	5,316	45	67
28.	IMI PLC	2,192,000	14,592	37	124
29.	Kingspan Group PLC	2,148,930	5,754	34	112
30.	BBA Aviation PLC	2,115,228	10,379	5	61
31.	Bakkavor Foods Ltd	2,057,963	14,636	4	14
32.	Molson Coors Brewing Company Ltd	2,048,837	2,311	2	11
33.	Burberry Group PLC	1,998,700	8,867	28	100
34.	Glanbia Public PLC	1,849,298	3,823	10	64
35.	Daily Mail And General Trust PLC	1,746,800	12,130	6	30

36.	Rolls-Royce Power Engineering PLC	1,741,527	2,508	2	45
37.	Premier Foods Group Ltd	1,734,935	9,327	2	12
38.	Meggitt PLC	1,605,800	10,831	8	64
39.	AB Agri Ltd	1,603,265	1,006	2	7
40.	Cummins Ltd.	1,596,434	3,866	5	7
41.	Aggreko PLC	1,583,200	5,316	45	67
42.	J.C. Bamford Excavators Limited	1,552,910	1,951	33	16
43.	Northern Foods Ltd	1,504,441	9,034	2	29
44.	Dairy Crest Ltd	1,444,800	5,973	2	26
45.	Roche Products Ltd	1,423,258	1,375	2	9
46.	Britvic Soft Drinks Ltd	1,399,157	2,179	2	15
47.	Dairy Crest Group PLC	1,381,600	5,283	2	8
48.	Kingspan Group PLC	1,361,806	5,754	34	112
49.	Glen Electric Ltd	1,349,805	5,160	2	17
50.	PZ Cussons PLC	1,331,639	7,336	2	24
51.	Fenner PLC	1,315,587	4,970	11	41
52.	Mcbride PLC	1,269,928	5,112	13	27
53.	Spectris PLC	1,230,800	7,361	5	41
54.	Chemring Group PLC	1,193,068	4,215	2	42
55.	Doncasters Ltd	1,169,771	752	2	12
56.	Greencore Group PLC	1,164,689	9,726	3	24
57.	Philips Electronics UK Ltd	1,160,348	2,058	11	17
58.	Greggs PLC	1,159,044	20,021	2	9
59.	Bentley Motors Ltd	1,154,900	3,460	6	30
60.	Agustawestland Ltd	1,101,179	3,525	6	18
61.	Yara UK Ltd	1,054,895	266	2	18
62.	Aggregate Industries UK Ltd	1,071,634	4,380	2	64
63.	Croda International PLC	1,051,900	3,272	28	59
64.	British Sugar PLC	1,050,500	2,243	3	6
65.	Spirax-Sarco Engineering PLC	1,044,199	4,706	9	63
66.	Guinness Peat Group PLC	1,043,000	22,084	6	27
67.	Morgan Advanced Materials PLC	1,007,500	10,033	2	72
68.	AB Agri Ltd	990,220	1,006	2	7
69.	Bombardier Transportation UK Ltd	979,561	2,696	2	7
70.	ABB Ltd	964,085	1,999	6	5
71.	Halma PLC	928,335	4,347	4	92
72.	Ineos Chlorvinyls Ltd	910,498	936	2	9
73.	DS Smith Paper Ltd	862,996	1,418	13	6
74.	Doosan Power Systems Ltd	830,213	4,378	2	2
75.	Rotork P.L.C.	807,537	2,581	6	19
76.	Prysmian Cables & Systems Ltd	791,918	1,097	7	9

77.	Crown Packaging UK PLC	775,955	1,554	2	7
78.	Elementis PLC	734,879	1,323	3	13
79.	Titan Europe PLC	713,095	2,666	2	8
80.	Dechra Pharmaceuticals PLC	664,752	1,042	7	13
81.	Thales UK Limited	565,472	1,954	6	24
82.	Hill & Smith Holdings PLC	695,425	3,652	5	45
83.	Langley Holdings PLC	674,541	2,264	2	23
84.	Tennants Consolidated Ltd	621,858	988	2	16
85.	Weetabix Ltd	559,641	1,076	2	9
86.	Bernard Matthews Ltd	532,647	3,209	3	20
87.	Volex PLC	518,773	8,401	4	26
88.	Renishaw P L C	517,851	2,765	3	44
89.	Borregaard Industries Ltd	509,494	779	2	6
90.	BAE Systems Global Combat Systems Munitions Ltd	505,575	1,501	26	8
91.	Luxfer Holdings PLC	496,650	1,520	1	7
92.	Robert Mcbride Ltd	491,841	1,986	6	22
93.	DU Pont (U.K.) Ltd	485,363	688	4	10
94.	Marshalls Mono Ltd	471,333	2,101	7	24
95.	Spirent Communications PLC	458,595	1,545	9	28
96.	Sunseeker International Ltd	451,928	2,170	2	7
97.	Hanson Building Products Ltd	421,097	1,674	2	11
98.	Wartsila Hamworthy Ltd	416,016	1,112	2	15
99.	Innospec Ltd	396,357	400	2	6
100.	AGA Rangemaster Group PLC	385,979	2,497	9	62
101.	Devro PLC	380,407	2,220	6	10
102.	A.G. Barr P.L.C.	374,196	972	2	10
103.	Victrex PLC	355,878	607	5	8
104.	James Halstead PLC	353,150	832	1	15
105.	Chesapeake Ltd	343,594	1,972	6	14
106.	Thorntons PLC	338,810	3,778	4	17
107.	Photo - ME International PLC	337,970	1,128	1	33
108.	Renold PLC	335,389	2,584	1	28
109.	Kone PLC	332,033	1,653	2	6
110.	Norcros PLC	320,660	1,630	5	6
111.	Aveva Group PLC	313,672	1,053	1	27
112.	Scapa Group PLC	313,136	1,167	1	24
113.	Federal-Mogul Ltd	294,297	1,321	3	20
114.	Cummins Generator Technologies Ltd	293,327	708	6	14
115.	Norbrook Laboratories Ltd	283,380	1,533	7	11

116.	GE Healthcare Ltd	283,045	1,408	14	18
117.	Psion PLC	272,114	926	2	35
118.	Portakabin Ltd	271,890	1,351	5	7
119.	Score Group PLC	243,629	1,341	3	7
120.	Consort Medical PLC	229,181	1,163	2	7
121.	Coopervision Manufacturing Ltd	224,664	2,300	2	11
122.	Cadbury Ltd	219,484	1,217	4	17
123.	Andrew Industries Ltd	217,492	1,248	2	11
124.	Depuy International Ltd	215,124	651	2	8
125.	Pitney Bowes Ltd	213,278	1,692	3	4
126.	B & W Group Ltd	211,061	562	3	14
127.	Assa Abloy Ltd	209,959	836	2	17
128.	A.E.S. Engineering Ltd	208,088	1,460	2	13
129.	Anite PLC	199,272	492	11	23
130.	W.Lucy & Co.Limited	197,626	872	2	12
131.	Oxford Instruments Nanotechnology Tools Ltd	197,082	475	4	9
132.	John Cotton Group Limited	193,886	806	2	16
133.	Intersurgical Ltd	189,619	646	14	14
134.	Spirax-Sarco Ltd	184,711	1,157	7	13
135.	Goodwin PLC	175,474	949	8	26
136.	Avon Rubber P.L.C.	172,654	718	2	13
137.	The Alumasc Group PLC	172,599	776	2	34
138.	Anglia Maltings (Holdings) Limited	172,190	220	2	14
139.	AFE Group Ltd	171,734	1,168	2	8
140.	John Guest Ltd	162,106	950	6	8
141.	Crane Ltd	160,000	570	2	16
142.	Senator International Ltd	156,080	978	3	14
143.	Abcam PLC	152,658	405	4	8
144.	Molins Public Ltd Company	146,754	741	8	25
145.	Tetrosyl Ltd	145,159	476	3	9
146.	Diodes Zetex Semiconductors Limited	144,233	358	3	6
147.	Altro Limited	134,274	486	2	12
148.	Hadley Industries Holdings Limited	130,138	368	1	22
149.	Warwick International Group Limited	127,133	224	2	6
150.	Acco UK Limited	103,692	402	2	7

APPENDIX 3

Constructing the matched patent - MNE and subsidiary database

Step	Description	Methodological considerations	Source
Sample specification	The population of UK headquartered manufacturing MNEs was identified. A sample of 150 MNEs was selected based on their latest operating revenue and provided they recorded 1 or more patents in the 2003-2012 period. For the 150 MNEs a list of all subsidiaries and their main features including country of operation was extracted.	The database permitted for comprehensive identification information for each MNE, most importantly capturing any previous company names and date of name change.	FAME
Patent counts (total)	Count of total number of patents granted to headquarters and all first level subsidiaries in the 2003-2012 period	Search is based using the *Applicant* information in the detailed description of each individual patent. Applicant information gives the name and country of the person, firm or institution filing for the patent. EPO does not keep a unique number identifier for the applicant, the name of the applicant is the main identifier in the search process. In certain cases the applicant information does not contain the full registered name of the applicant (firm), in the search process multiple steps were taken. In the first step, search based on the full name of the company was made (as stated in the identification information derived from FAME). In the second step, the legal incorporation form was omitted (e.g. in Vodafone Group PLC the extension PLC was omitted in the search process). In the third step, companies which had extensions to their name that were generic were omitted in the search process, to ensure that all the patents granted to a firm were considered (e.g. in Vodafone Group PLC the extension Group was omitted in the search process).	EPO, FAME

		The publication year is the year on which a patent application is first published. If the MNE or subsidiary changed their name during the period, this was taken into account during the search process.	
Patent counts (single country)	Count of number of patents granted to headquarters and all first level subsidiaries in the 2003-2012 period if all applicants operate in the same country.	Two or more applicants, all from same country listed on the patent information. One of the applicants being the MNE headquarter or first level subsidiary (when matched to the original identification information from FAME), evidenced by applicant name and country.	EPO, FAME
Patent counts (international)	Count of number of patents granted to headquarters and all first level subsidiaries in the 2003-2012 period if more than one applicant operates in a different country.	Two applicants from two different countries listed on the patent information as a minimum. One of the applicants being the MNE headquarter or first level subsidiary (when matched to the original identification information from FAME), evidenced by applicant name and country.	EPO, FAME
Patent counts (international internal)	Count of number of patents granted to headquarters and all first level subsidiaries in the 2003-2012 period if more than one applicant operates in a different country AND if all applicants belong to the same MNE group.	Two or more applicants from at least two different countries listed on the patent information. All applicants needed to be either headquarters or subsidiaries of the same MNE (when matched to the original identification information from FAME), evidenced by applicant name and country.	EPO, FAME
Patent counts (international external)	Count of number of patents granted to headquarters and all first level subsidiaries in the 2003-2012 period if more than one applicant operates in a different country AND if one or more applicants do not belong to the same MNE group.	Two applicants from two different countries listed on the patent information. At least one of the applicants being the MNE headquarter or first level subsidiary (when matched to the original identification information from FAME) and other applicant(s) must not be a subsidiary of the same MNE, evidenced by applicant name and country.	EPO, FAME

APPENDIX 4

Fixed and random effects estimation and Hausmann test results based on the baseline model:

$$\varepsilon_{it} = \beta_0 + \beta_1 \varepsilon_{it-1} + \beta_2 Pd_i + \beta_3 C_i + \beta_4 IA_{it} + \beta_5 A_{it} + \beta_6 S_{it} + v_{it}$$

where ε_{it} is the TFP estimate, Pd_i is product diversity, C_i is the number of countries in which the MNE operates, IA_{it} intangible assets, A_{it} signifies age, S_{it} refers to size and v_{it} is the error term. The model also includes fixed effects for years and industries.

	Baseline model		Hausman test
Dependent variable	TFP	TFP	Difference
	(1)	(2)	(3)
Independents			
Lag of dependent variable	.067*	.015	
	(1.98)	(0.51)	
Single country patents	.019	-.004	.013
	(1.38)	(-1.03)	
Product diversity	omitted	.009	
		(0.86)	
Number of countries in which MNE operates	omitted	-.014†	
		(-1.84)	
Intangible Assets	-.007*	.001	.003
	(-2.01)	(0.62)	
Age	.016	-.028**	.069
	(0.24)	(-3.04)	
Size (dummy)	-.001	.030*	.022
	(-0.03)	(1.97)	
Time (dummy)	Included	Included	
Industry (dummy)	Included	Included	
(Constant)	-.009	.089†	
	(-0.04)	(1.84)	

R-squared within	0.009	0.001	
R-squared between	0.610	0.143	
R-squared overall	0.577	0.017	
F/ chi2	0.85	21.25	
Prob>chi2			**0.337**
Number of observations	1350	1350	
Estimation method	Panel fixed effects	Panel random effects	

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. The values in brackets represent respective t-values in column 1 and z values in column 2. The null hypothesis is that the coefficients estimated by the random effects estimator are the same as the ones estimated by the fixed effects estimator.

APPENDIX 5

Wald test for the explanatory variables introduced in model 2, Table 4.3.

(1) Lagged dependent variable =0
(2) International patents, internal =0
(3) International patents, internal^2=0
(4) International patents, external =0
(5) International patents, external^2=0
(6) Single country patents=0
(7) Product Diversity = 0
(8) Number of countries in which MNE operates = 0
(9) Intangible Assets=0
(10) Age = 0
(11) Size= 0
(12) Time dummies =0
(13) Industry dummies =0

F (11, 149) = 1101.65
Prob > F = 0.0000

APPENDIX 6

The effect of international internal and external knowledge on TFP, estimated using OLS and random effects

	Hypothesis	Production function	Baseline model	Model 2	Production function	Baseline model	Model 2
Dependent variable:		Turnover	TFP	TFP	Turnover	TFP	TFP
		(1)	(2)	(3)	(4)	(5)	(6)
Independents							
Lag of dependent variable					.960***	.015	.014
					(.006)	(.030)	(.030)
Total Assets		.142***			.005*		
		(.025)			(.002)		
Number of Employees		.115**			.010		
		(.043)			(.006)		
International patents, internal	H1			**-.090***			**-.015***
				(.024)			**(.006)**
International patents, internal²	H1			**.048****			.005
				(.022)			(.006)
International patents, external	H2			**-.285*****			-.004
				(.014)			(.003)
International patents, external²	H2			**.073*****			.004
				(.021)			(.005)
Controls							
Single country patents			-.093***	-.088***		-.004	-.003
			(.025)	(.024)		(.004)	(.004)
Product diversity			-.267***	-.203***		.009	.015
			(.051)	(.052)		(.010)	(.010)
Number of countries in which MNE operates			-.199***	-.154***		-.014†	-.009
			(.036)	(.038)		(.007)	(.008)
Intangible Assets			.017*	.016*		.001	.001
			(.008)	(.008)		(.001)	(.001)

Age		-.072*	-.076*		-.028**	-.027**
		(.034)	(.034)		(.009)	(.009)
Size (dummy)		1.627***	1.575***		.030*	.024
		(.065)	(.066)		(.015)	(.015)
Time (dummy)	Included	Included	Included	Included	Included	Included
Industry (dummy)	Included	Included	Included	Included	Included	Included
(Constant)	10.018***	.400*	.040	.362***	.089†	-.010
	(.368)	(.202)	(.231)	(.008)	(.048)	(.067)
R-squared	0.20	0.406	0.421			
R-squared within				0.536	0.001	0.003
R-squared between				0.997	0.143	0.171
R-squared overall				0.976	0.017	0.027
F	19.39	50.90	53.66			
Wald chi2				31526.23	21.25	33.57
Number of observations	1500	1500	1500	1350	1350	1350
Estimation method	OLS robust	OLS robust	OLS robust	Random effects	Random effects	Random effects

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors are in parentheses. Model 2 in column 3 does not show multicollinearity concerns (average variance inflation level is below the threshold).

APPENDIX 7

The effect of international internal and external knowledge on TFP, higher and lower technology groups

	Hypothesis	Production function	Baseline model	Model 1	Model 2	Production function	Baseline model	Model 1	Model 2
		Higher technology MNEs				Lower technology MNEs			
Dependent variable:		Turnover (1)	TFP (2)	TFP (3)	TFP (4)	Turnover (1)	TFP (2)	TFP (3)	TFP (4)
Independents									
Lagged dependent variable		.258*** (.005)	.857*** (.006)	.852*** (.014)	.850*** (.016)	.570*** (.010)	.270*** (.009)	.248*** (.014)	.289*** (.014)
Total assets		-.022 (.001)				.026*** (.001)			
Number of employees		.418*** (.011)				.141*** (.010)			
International patents, internal	H1			**.009*** **(.004)**	**.061**** **(.020)**			**-.096***** **(.010)**	**-.213***** **(.047)**
International patents, internal²	H1				**-.011**** **(.003)**				**.034***** **(.009)**
International patents, external	H2			**-.005*** **(.002)**	**-.032** **(.021)**			**-.018*** **(.002)**	**-.039†** **(.020)**
International patents, external²	H2				**.010*** **(.005)**				**.012*** **(.005)**
Controls									
Single country patents			.008* (.003)	.009* (.004)	.004† (.002)		-.128** (.006)	-.100*** (.007)	-.095*** (.005)
Product diversity			-.035*** (.009)	-.013 (.009)	-.024* (.009)		.127*** (.029)	.096* (.037)	.115*** (.033)
Number of countries in which MNE operates			-.010† (.006)	-.019*** (.005)	-.012* (.005)		-.037 (.027)	-.058* (.028)	-.031 (.023)

Intangible Assets		.018***	.013***	.017***		.025	.046***	.033***
		(.001)	(.001)	(.001)		(.002)	(.004)	(.004)
Age		-.017*	-.028*	-.009		-.057*	-.036	-.042
		(.006)	(.001)	(.010)		(.025)	(.026)	(.032)
Size (dummy)		.096***	.124***	.134***		.623***	.681***	.566***
		(.015)	(.014)	(.023)		(.042)	(.045)	(.045)
Time (dummy)	Included	Included	Included	Included	Included	Included	Included	Included
Industry (dummy)	Included	Included	Included	Included	Included	Included	Included	Included
(Constant)	6.933***	1.957***	2.014***	2.162***	4.164***	8.92***	8.456***	6.218***
	(.093)	(.077)	(.148)	(.315)	(.155)	(.176)	(.270)	(.573)
AR(2) z-value	-1.96	-1.65	-0.80	-0.74	0.41	-1.31	-1.27	-1.19
Sargan test	336.52	104.64	173.25	242.54	734.78	607.45	201.65	288.46
Hansen test	63.20	61.97	53.58	53.13	61.38	60.90	61.30	51.92
Number of instruments	78	76	151	155	112	101	125	139
F value	380.25	422.89	464.38	572.57	322.22	370.19	387.69	465.72
Number of observations	657	657	657	657	693	693	693	693
Estimation method	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors in parentheses. Lagged dependent variable, Total assets, Number of employees, Intangible assets and particular knowledge based indicators were considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets. Model 2 is the full model (expression 4.5.), whereas Model 1 excludes the squared values of the two main independent variables.

APPENDIX 8

Wald test for the explanatory variables introduced in model 1, Table 5.3.

(1) Lagged dependent variable =0
(2) Balance single country/international patents = 0
(3) Product Diversity = 0
(4) Number of countries in which MNE operates = 0
(5) Intangible Assets=0
(6) Age = 0
(7) Size= 0
(8) Time dummies =0
(9) Industry dummies =0

F (7, 149) = 214.50
Prob > F = 0.0000

APPENDIX 9

Wald test for the explanatory variables introduced in model 2, Table 5.3.

(1) Lagged dependent variable =0
(2) Balance international internal/external patents = 0
(3) Single country patents=0
(4) Product Diversity = 0
(5) Number of countries in which MNE operates = 0
(6) Intangible Assets=0
(8) Age = 0
(9) Size= 0
(10) Time dummies =0
(11) Industry dummies =0

F (7, 149) = 399.52
Prob > F = 0.0000

APPENDIX 10

The effect of balance of single country and international knowledge and balance of internal and external international knowledge on TFP, estimated using OLS and random effects

	Hypothesis	Model 1	Model 2	Model 1	Model 2
Dependent variable:		TFP	TFP	TFP	TFP
		(1)	(2)	(3)	(4)
Independents					
Lag of dependent variable				.015	.017
				(.030)	(.030)
Balance single country/international patents	H1	**.047*** **		**.004***	
		(.009)		**(.002)**	
Balance international internal/ external patents	H2		**.046*** **		**.007***
			(.012)		(.003)
Controls					
Single country patents			-.092***		-.002***
			(.025)		(.004)
Product diversity		-.272***	-.263***	.009	.012
		(.052)	(.051)	(.010)	(.010)
Number of countries in which MNE operates		-.206***	-.196***	-.013†	-.010
		(.035)	(.036)	(.007)	(.007)
Intangible Assets		.016**	.017*	.001	.001
		(.007)	(.008)	(.001)	(.001)
Age		-.063†	-.071*	-.027**	-.027**
		(.035)	(.034)	(.009)	(.009)
Size (dummy)		1.644***	1.624***	.030*	.026*
		(.063)	(.065)	(.015)	(.015)
Time (dummy)		Included	Included	Included	Included
Industry (dummy)		Included	Included	Included	Included

(Constant)	.325 (.209)	.340 (.230)	.076 (.048)	.017 (.056)
R-squared	0.400	0.406		
R-squared within			0.001	0.002
R-squared between			0.146	0.144
R-squared overall			0.020	0.022
F	48.53	49.36		
Wald chi2			24.27	27.42
Number of observations	1500	1390	1350	1251
Estimation method	OLS robust	OLS robust	Random effects	Random effects

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors in parentheses. For testing model 2 a reduced sample was used, 11 MNEs which did not record any international patents in the period were excluded.

APPENDIX 11

The effect of balance between single country and international knowledge creation and balance between international internal and external knowledge creation on TFP, higher and lower technology groups

	Hypothesis	Model 1	Model 2	Model 1	Model 2
		Higher technology MNEs		Lower technology MNEs	
Dependent variable:		TFP	TFP	TFP	TFP
		(1)	(2)	(3)	(4)
Independents					
Lagged dependent variable		.847***	.855***	.303***	.308***
		(.006)	(.008)	(.016)	(.014)
Balance single country/international patents	H5.1.	**.006*** **		**.027***	
		(.001)		**(.003)**	
Balance international internal/ external patents	H5.2.		**.004****		**.006***
			(.001)		**(.003)**
Controls					
Product diversity		-.031**	-.033***	.134***	.132***
		(.008)	(.009)	(.031)	(.038)
Number of countries in which MNE operates		-.014*	-.007	-.053†	-.077**
		(.008)	(.006)	(.030)	(.028)
Intangible Assets		.016***	.016***	.024***	.024***
		(.001)	(.001)	(.002)	(.002)
Age		-.014*	-.013†	-.003	-.008
		(.008)	(.007)	(.038)	(.039)
Size (dummy)		.115***	.115***	.641**	.661***
		(.010)	(.013)	(.051)	(.045)
Time (dummy)		Included	Included	Included	Included
Industry (dummy)		Included	Included	Included	Included
(Constant)		1.955***	1.856***	8.366***	8.214***
		(.098)	(.115)	(.064)	(.289)

AR(2) z-value	-1.30	-1.65	-1.21	-1.35
Sargan test	110.53	109.93	848.11	911.93
Hansen test	58.37	59.28	63.74	61.91
Number of instruments	83	83	85	85
F value	332.39	347.76	113.19	113.94
Number of observations	657	657	693	594
Estimation method	System GMM	System GMM	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. Standard errors in parentheses. Lagged dependent variable, Intangible assets and particular knowledge based independents were considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets. For testing models in column 2 and 4 a reduced sample was used, 11 MNEs which did not record international patents in the period were excluded as it was not possible to estimate the main independents for these MNEs.

APPENDIX 12

Wald test for the explanatory variables introduced in model 2, Table 6.3.

(1) Lagged dependent variable =0
(2) International patents, internal = 0
(3) International patents, internal² = 0
(4) International patents, external = 0
(5) International patents, external² = 0
(6) Environmental instability = 0
(7) International patents, internal x Environmental instability = 0
(8) International patents, internal² x Environmental instability = 0
(9) International patents, external x Environmental instability = 0
(10) International patents, external² x Environmental instability = 0
(11) Single country patents = 0
(12) Product Diversity = 0
(13) Number of countries in which MNE operates = 0
(14) Intangible Assets=0
(15) Age = 0
(16) Size= 0
(17) Time dummies =0
(18) Industry dummies =0

F (16, 149) = 458.91
Prob > F = 0.0000

APPENDIX 13

Wald test for the explanatory variables introduced in model 4, Table 6.3.

(1) Lagged dependent variable =0
(2) Balance single country/international patents = 0
(3) Environmental instability = 0
(4) Balance single country/international patents x Environmental instability = 0
(5) Product Diversity = 0
(6) Number of countries in which MNE operates = 0
(7) Intangible Assets=0
(8) Age = 0
(9) Size= 0
(10) Time dummies =0
(11) Industry dummies =0

F (9, 149) = 903.71
Prob > F = 0.0000

APPENDIX 14

Wald test for the explanatory variables introduced in model 6, Table 6.3.

(1) Lagged dependent variable =0
(2) Balance international internal/external patents = 0
(3) Environmental instability = 0
(4) Balance international internal/ external patents x Environmental instability = 0
(5) Single country patents=0
(5) Product Diversity = 0
(6) Number of countries in which MNE operates = 0
(7) Intangible Assets=0
(8) Age = 0
(9) Size= 0
(10) Time dummies =0
(11) Industry dummies =0

F (9, 149) = 952.68
Prob > F = 0.0000

APPENDIX 15

The moderating effect of environmental instability on the relationship between international internal and external knowledge and TFP and the relationship between the balance between single country and international and international internal and external knowledge and TFP, estimated using OLS and random effects

	Hypothesis	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Dependent variable:		TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Independents									
Lag of dependent variable						.014	.011	.015	.016
						(.030)	(.030)	(.030)	(.030)
International patents, internal		-.381***	-.319*			.010	.034		
		(.126)	(.140)			(.035)	(.038)		
International patents, internal²		.055**	.029			-.005	-.010		
		(.022)	(.026)			(.006)	(.007)		
International patents, external		-.293***	-.239**			-.022	-.022		
		(.089)	(.083)			(.021)	(.021)		
International patents, external²		.075***	.062***			.004	.004		
		(.021)	(.020)			(.006)	(.005)		
Balance international/ single country patents				.047***				.004*	
				(.009)				(.002)	
Balance internal/ external International patents					.019				.007**
					(.012)				(.003)
Environmental instability		-.146*	-.119*	-.196***	-.117	.001	.001	.001	-.011
		(.063)	(.062)	(.060)	(.103)	(.018)	(.019)	(.019)	(.028)
Interactions									
International patents, internal x Environmental instability	H6.1.		**-.778*** **				-.051		
			(.180)				(.050)		
International patents, internal² x Environmental instability	H6.1.		**.122*** **				.008		
			(.031)				(.009)		

International patents, external x Environmental instability	H6.2.		**.457*** (.104)**				-.016 (.030)		
International patents, external² x Environmental instability	H6.2.		**-.101*** (.025)**				.003 (.007)		
Balance single country/international patents x Environmental instability	H6.3.			**-.053*** (.013)**				-.002 (.003)	
Balance international internal/ external patents x Environmental instability	H6.4.				**.021* (.014)**				.002 (.003)
Controls									
Single country patents		-.092*** (.025)	-.096*** (.025)		-.095*** (.025)	-.003 (.004)	-.005 (.004)		-.002 (.004)
Product diversity		-.222*** (.051)	-.202*** (.051)	-.277*** (.050)	-.283*** (.051)	.015 (.010)	.017 (.010)	.010 (.010)	.012 (.010)
Number of countries in which MNE operates		-.165*** (.038)	-.149*** (.038)	-.241*** (.034)	-.210*** (.036)	-.009 (.008)	-.009 (.008)	-.014† (.007)	-.011 (.007)
Intangible Assets		.016* (.007)	.015* (.007)	.015* (.007)	.016* (.007)	.001 (.001)	.001 (.001)	.001 (.001)	.001 (.001)
Age		-.077* (.033)	-.070* (.033)	-.063† (.034)	-.065† (.033)	-.027** (.009)	-.030*** (.009)	-.027** (.009)	-.028** (.009)
Size (dummy)		1.562*** (.066)	1.531*** (.066)	1.646*** (.063)	1.619*** (.064)	.024 (.015)	.022 (.015)	.030* (.015)	.026† (.015)
Time (dummy)		Included	Included	Included	Included	Included	Included	Included	Included
Industry (dummy)		Included	Included	Included	Included	Included	Included	Included	Included
(Constant)		-5.189*** (.157)	-4.251** (.160)	-.723** (.264)	-.580† (.346)	-.008 (.281)	.165 (.298)	.079 (.067)	-.008 (.087)
R-squared		0.482	0.493	0.470	0.456				
R-squared within						0.00	0.00	0.001	0.002
R-squared between						0.17	0.18	0.142	0.144

R-squared overall					0.02	0.03	0.020	0.022
F	58.22	54.50	49.67	46.41				
Wald chi2					33.57	37.06	24.75	27.54
Number of observations	1500	1500	1500	1390	1350	1350	1350	1251
Estimation method	OLS robust	OLS robust	OLS robust	OLS robust	Random effects	Random effects	Random effects	Random effects

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. The values in brackets represent respective t-values. The average Variance inflation factor (VIF) values for the models in column 2, 3 and 4 are below the 10 value threshold (O'Brien, 2007). For testing models 4 and 8 a reduced sample was used, 11 MNEs which did not record any international patents in the period were excluded as it was not possible to estimate the main independents for these MNEs.

APPENDIX 16

The moderating effect of higher/lower technology industry dummy on the relationship between international internal and external knowledge creation and TFP, and the relationship between the balance between single country and international and international internal and external knowledge creation and TFP

	Hypothesis	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dependent variable:		TFP	TFP	TFP	TFP	TFP	TFP
		(1)	(2)	(3)	(4)	(5)	(6)
Independents							
Lagged dependent variable		.874***	.881***	.880***	.894***	.888***	.906***
		(.007)	(.006)	(.005)	(.005)	(.006)	(.004)
International patents, internal		-.006	-.048***				
		(.007)	(.001)				
International patents, internal²		.002†	.008***				
		(.001)	(.001)				
International patents, external		-.003	.030***				
		(.006)	(.006)				
International patents, external²		.001	-.005***				
		(.001)	(.001)				
Balance international/ single country patents				.014***	.013***		
				(.002)	(.002)		
Balance internal/ external International patents						-.009***	-.009***
						(.002)	(.001)
Higher/lower technology industry dummy		.019	.011	-.002	.036†	.018	.025
		(.018)	(.018)	(.023)	(.019)	(.083)	(.013)
Interactions							
International patents, internal x Higher/lower technology industry dummy	H1		**.065*** (.018)**				

International patents, internal² x Higher/lower technology industry dummy	H1		**-.011*** (.003)**				
International patents, external x Higher/lower technology industry dummy	H2		**-.021* (.009)**				
International patents, external² x Higher/lower technology industry dummy	H2		**.004* (.002)**				
Balance international/ single country patents x Higher/lower technology industry dummy	H3				**-.011*** (.003)**		
Balance internal/ external International patents x Higher/lower technology industry dummy	H4						**.006** (.002)**
Controls							
Single country patents		-.001 (.001)	-.011*** (.001)			-.024* (.010)	-.008* (.002)
Product diversity		.031*** (.015)	023*** (.006)	.038*** (.006)	.034*** (.006)	.041*** (.006)	.022*** (.005)
Number of countries in which MNE operates		-.017*** (.004)	-.018*** (.003)	-.008* (.004)	-.014*** (.003)	.004 (.005)	-.011*** (.003)
Intangible Assets		-.001 (.001)	.002 (.001)	-.001 (.001)	-.001 (.001)	-.001 (.001)	-.001 (.001)
Age		-.027*** (.005)	-.023*** (.005)	-.023*** (.006)	-.026*** (.005)	-.017** (.006)	-.024*** (.004)
Size (dummy)		.111*** (.013)	.091*** (.010)	.099*** (.011)	.086*** (.010)	.082*** (.011)	.071*** (.008)
Time (dummy)		Included	Included	Included	Included	Included	Included
Industry (dummy)		Included	Included	Included	Included	Included	Included

(Constant)	1.601***	1.362***	1.456***	1.316***	1.247***	1.319***
	(.143)	(.106)	(.079)	(.069)	(.081)	(.066)
AR(2) z-value	-1.60	-1.51	-1.09	-0.95	-1.26	-1.47
Sargan test chi² value	273.35	254.31	198.45	259.25	265.01	296.15
Hansen test chi² value	114.76	114.09	82.40	112.48	113.96	122.08
Number of instruments	131	135	111	112	113	122
F value	579.64	608.24	590.00	758.43	601.62	646.36
Number of observations	1350	1350	1350	1350	1251	1251
Estimation method	System GMM	System GMM	System GMM	System GMM	System GMM	System GMM

Notes: †, *, **, and *** denote significance at 10%, 5%, 1%, and 0.1% levels respectively. The values in brackets represent respective t-values. Lagged dependent variable, Intangible assets and particular knowledge based indicators were considered as not strictly exogenous, based on the values of the Hansen tests of exogeneity of instrument subsets. For operationalising the interaction terms in model 2, we apply the residual centering procedure to ensure there is no multicollinearity, explained in detail in chapter six section 5. For testing models 5 and 6 a reduced sample was used, 11 MNEs which did not record any international patents in the period were excluded as it was not possible to estimate the main independents for these MNEs.