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**KNOWLEDGE OUTFLOWS FROM FOREIGN SUBSIDIARIES: THE TENSION BETWEEN
KNOWLEDGE CREATION AND KNOWLEDGE PROTECTION**

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Abstract

This paper analyzes the MNC subsidiaries' trade-off between the need for knowledge creation and the need for knowledge protection, and relates it to the extent of knowledge outflows generated within the host location. Combining research in International Business with Social Theory, we find that subsidiaries that extensively draw on external knowledge sources are also more likely to generate knowledge outflows to local firms. We argue that this may be explained by the subsidiaries' willingness to build the trust that facilitates the establishment of reciprocal knowledge linkages. However, when the value of the subsidiary's knowledge stock is very high, the need for knowledge protection restrains reciprocity mechanisms in knowledge exchanges, thus reducing the extent of knowledge outflows to the host location. This study contributes to the literature on the firm-level antecedents of FDI-mediated local knowledge outflows, as well as to the broad IB literature on the relationship between subsidiaries and their host regions. The implications for managers and policy-makers are also discussed.

JEL Classification: *032, M16*

Keywords: local knowledge outflows, FDI, knowledge creation, knowledge protection

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1. INTRODUCTION

A widely investigated topic in the field of international business (IB) is the globalization of the innovative activities of Multinational Corporations (MNCs), particularly in high-technology sectors (Phene & Almeida, 2008). Since the pioneering works that attributed the very existence of MNCs to the failure of the international market for technology (Buckley & Casson, 1976), a growing body of literature has started to look at MNCs as geographically distributed networks of innovation, whose main ability is to assimilate, create and integrate knowledge on a global basis (Kogut & Zander, 1993; Birkinshaw, 1997; Frost *et al.*, 2002).

An important consequence of MNCs' international distribution of innovation resides in the phenomenon of the *knowledge flows to the host-location*. Indeed, beyond absorbing knowledge from local sources of expertise, MNCs' foreign subsidiaries also diffuse – either intentionally and unintentionally - some of their knowledge to domestic firms (Almeida, 1996), through the process of local interaction (Haskel *et al.*, 2007). Much literature has analysed the direction, the scope, the channels and the antecedents of such knowledge flows (Teece, 1977; Rodriguez-Clare, 1996; Song *et al.*, 2003; Feinberg & Majumdar, 2001; Giroud & Scott-Kennel, 2009). However, an accurate analysis of the extant literature still reveals some gaps.

In the first place, while there is plenty of analysis regarding the *country-level* and *industry-level* determinants of this phenomenon, the influence that *the firm* itself (and, in particular, its subsidiaries) may exert on the patterns of local knowledge outflows remains an under investigated topic. Notable exceptions have tried to account for the role of the MNCs' investing motive (Chung, 2001; Driffield & Love, 2007), of the relationships with the MNC internal network (Zhao, 2006; Driffield *et al.*, 2010), and of the type of activity realized abroad by foreign facilities (Branstetter, 2006; Marin & Bell, 2006). Despite these contributions, research has failed to look at how *the subsidiary's strategy*, in terms of the management of its knowledge assets, affects the extent of the knowledge that flows to domestic firms. However, this issue is relevant since it is by now recognized that subsidiaries can *actively* manage their knowledge resources within their local

context (Birkinshaw & Hood, 1998; Cantwell & Mudambi, 2005), thus generating heterogeneous patterns of interaction with the local knowledge network and, hence, different levels of knowledge outflows.

In addition, IB and strategy literature has looked at the knowledge exchange relationships between subsidiaries and domestic firms from two different perspectives. Traditional research on subsidiary innovation (Almeida & Phene, 2004; Phene & Almeida, 2008), mandate (Birkinshaw & Hood, 1998; Cantwell & Mudambi, 2005) and embeddedness (Andersson *et al.*, 2002; 2007) has highlighted the role of the local firms as a source of valuable resources and knowledge. On the other hand, literature on the knowledge protection strategies of multinational firms (Alcacer & Chung, 2007; De Faria & Sofka, 2010; Shaver & Flyer, 2000; Zhao, 2006) has pointed to the threats, in terms of knowledge spillover, arising from the contact with the local context. An integrated analysis of the double role the interaction with domestic firms plays for a subsidiary's competitiveness is still missing.

In this paper, we try to fill these gaps by explicitly analyzing how the opportunities and challenges subsidiaries face in the local knowledge network influence the patterns of knowledge outflows they generate to the host location. We conceptualize the mechanism that drives the subsidiaries' management of their knowledge assets as the *tension between knowledge creation and knowledge protection*. A subsidiary's knowledge creation is highly dependent on its ability to leverage external resources (Almeida & Phene, 2004). We suggest that the access to such resources is facilitated by the involvement in reciprocal exchange relationships (Håkansson & Snehota, 1989; Johanson & Mattsson, 1992; Kachra & White, 2008), which consequently boost the knowledge outflows to local firms. However, such relationships – through which knowledge flow bidirectionally - can also be detrimental for subsidiaries' competitive standing in the foreign location, especially when their knowledge is highly valuable. In this latter case, subsidiaries might be driven to strengthen their knowledge protection strategies when interacting with the local environment, thus reducing the level of knowledge outflows.

This paper aims to demonstrate that the differences in patterns of local knowledge outflows generated by MNCs' foreign subsidiaries can be explained by accounting for the trade-off between knowledge creation and knowledge protection they face within their host location. The need for knowledge creation is captured through the analysis of subsidiaries' *external focus in knowledge sourcing*, which allows us to explore what the consequences, in terms of local knowledge outflows, of subsidiaries' ability to absorb knowledge from external sources. Additionally, we focus on subsidiaries' *knowledge value* as the condition that activates the need for knowledge protection.

We use patent citation data to test our models, performing negative binomial regression analysis on a panel dataset of US subsidiaries of foreign MNCs, and try to address the question: *How does the tension between knowledge creation and knowledge protection influence the extent of a subsidiary's knowledge outflows to the host-location?* Empirical results suggest that an external focus in knowledge sourcing generates higher levels of knowledge outflows. However, in the presence of a high value of subsidiaries' knowledge stock, subsidiaries tend to increasingly protect their knowledge assets. Hence, they limit reciprocity behaviors in knowledge exchanges and reduce the extent of local knowledge outflows.

Our study contributes to the literature on FDI knowledge outflows, by accounting for the double role host locations play for subsidiaries' competitiveness. Previous research has analyzed either subsidiaries' knowledge exchange dynamics (Almeida, 1996; Singh, 2007) or MNCs' strategies to prevent knowledge leakage (Alcacer & Chung, 2007). No study has accounted for the simultaneous effects that the need for knowledge creation and the need for knowledge protection exert on the phenomenon of local knowledge outflows. We believe that this focus will provide a more comprehensive understanding of how subsidiaries find a balance between such conflicting forces, and shed more light on the subsidiary-level antecedents of FDI local knowledge outflows. In addition, by highlighting some of the social mechanisms underpinning FDI-mediated local knowledge outflows, we provide a much more socially enriched description of this phenomenon.

This analysis can also be an important source of strategic considerations for practitioners involved in the management of cross-border knowledge investment in MNCs. Subsidiaries' managers must be aware that, in order to explore and acquire external knowledge, it's important to reciprocally contribute to the host-location knowledge assets. However, when subsidiaries have too much to lose in such knowledge exchange relationships, managers can lower their involvement with local firms and have recourse to higher knowledge protection barriers, to the aim of avoiding the diffusion of their competitive assets.

The rest of the paper is organized as follows. In the next section, we review the existing research on subsidiaries' knowledge flows and knowledge management. We then elaborate on the "trade-off" between knowledge creation and knowledge protection, and develop hypotheses. Finally, we present our model and discuss the empirical results.

2. LITERATURE REVIEW

2.1 Knowledge flows and knowledge spillovers: an overview of country, industry and firm level determinants

IB theory has highlighted that the localization of FDI generates positive externalities for host-country firms. This finding has fostered the development of a substantial strand of literature on FDI-mediated spillovers to host-countries (for a review, see, Görg & Greenaway, 2003). Spillovers from FDI may take different forms. Beyond the ability to boost local employment and to pull in large capital inflows, the embedding of multinational operations may result in knowledge outflows, which span MNCs affiliates' boundaries through several channels. Established literature suggests that knowledge flows from MNCs to host-country firms derive from the technological assets generated by parent companies (Caves, 1974), which can be transferred to subsidiaries located abroad (Dunning, 1981). When this transfer takes place, the interaction between MNCs' subsidiaries and the local firms may produce local knowledge outflows, allowing host-country firms to access MNCs' technology (Haskel *et al.*, 2007).

Traditional theory predicts that MNCs belonging to countries, or to industries within a country, that are more advanced than host country organizations, are more likely to generate knowledge-based spillovers (Findlay, 1978). Yet, host country firms are required to have a minimum level of absorptive capacity to internalize such knowledge (Glass & Saggi, 1998). Empirical literature has also found that the patterns of the FDI knowledge outflows are governed by relevant *cross-countries*, as well as *cross-industries* differences (Narula & Dunning, 2000; Singh, 2007).

In a departure from these “*macro-level*” analyses of the antecedents of FDI-mediated knowledge spillovers, in recent years, scholars have recognized that also the *firm heterogeneity* may play a role in this phenomenon. As an example, Chung (2001) and Driffield & Love (2007) find that the firms’ investing motive influences the FDI knowledge spillover effect. In his research on Japanese investors in the United States, also Branstetter (2006) focuses on firm-level characteristics, and shows that FDI are more likely to generate knowledge outflows to American firms when they take the form of greenfield production facilities and distribution centers, since they are supposed to embody the parent firms’ technological superiority. Conversely, Driffield *et al.* (2010) suggest that subsidiaries that receive more of the parent firm’s technology do not share knowledge with local firms. Finally, Marin & Bell (2006) propose the “*active subsidiary model*”, and show that subsidiaries’ own technological activity is an important determinant of the knowledge outflows to host country firms.

While being very important in shedding some lights on the firm-specific determinants of the FDI-mediated local knowledge diffusion, these studies seem to focus on the *structural* characteristics of subsidiaries (e.g. type of facility, type of local activity), thus overlooking the potential impact of subsidiaries’ *strategy*. One reason for this gap may be that traditional literature has considered subsidiaries as *passive actors* of both the MNC and the host-country networks (Alcacer & Chung, 2007; De Faria & Sofka, 2010), whose aim is just to implement the tasks assigned by the headquarters, with scarce - if any – autonomy in terms of strategy-making. However, recent IB literature (Ensign, Birkinshaw & Frost, 2000; Holm & Pedersen, 2000) has highlighted the

importance of examining firms' strategic behaviour also "*at the level of the subsidiary, rather than the level of the corporate group as a whole*" (Cantwell & Mudambi, 2005). Indeed, MNCs' subsidiaries have been found to be increasingly active in terms of the management of their knowledge assets (Mudambi & Navarra, 2004; Cantwell & Mudambi, 2005; Marin & Bell, 2006). Based on this reasoning, we believe that – in order to gain a more comprehensive understanding of the firm-level determinants of the local knowledge outflows generated by FDI – a closer look at how subsidiaries manage their knowledge needs in the host location is required.

2.2 Local firms in IB literature: opportunities and challenges for subsidiaries' knowledge management

Traditional IB research has looked at the local context as the source of valuable resources, to which subsidiaries should gain access in order to be successful within their internal and external networks, see e.g., Almeida & Phene (2004) who show that the host-country's technological diversity increases foreign subsidiaries' knowledge creation capability. Similarly, Phene & Almeida (2008) demonstrate that the knowledge assimilated from host-country firms is positively associated with both the scale and the quality of a subsidiary innovation. Also Birkinshaw & Hood (1998) and Cantwell & Mudambi (2005) elaborate on the importance of the local context for subsidiaries' acquisition of competence-creating mandate. Finally, Andersson *et al.* (2002, 2007) suggest that the embeddedness with local firms increases the subsidiary performance, as well as its importance and power within the MNC internal network. Based on this logic, the host location is an opportunity, and the interaction with local firms is desirable and beneficial.

A different perspective on the role of host country for MNCs arises from research on firms' heterogeneity and agglomeration dynamics. Alcacer & Chung (2007) and Shaver & Flyer (2000) have suggested that the host country can be a threat for MNCs' competitive position, and have analyzed the strategies that leading MNCs use to manage and protect their knowledge from the risk of local knowledge outflows. Their works show that MNCs assess their location choices based on

an accurate evaluation of the net (inward vs. outward) knowledge spillover. As a consequence, technologically advanced MNCs avoid agglomerating with highly concentrated clusters of related industrial activities, in order to protect their knowledge from external appropriation. Also Zhao (2006) considers the risks of conducting R&D in countries with weak Intellectual Property Rights, and finds that MNCs seek to internalize their technology by using it more extensively within the MNCs' network. Finally, recent empirical evidence suggests that, in presence of very high local competition, subsidiaries reduce the investment into their vertical local linkages to limit the risk of local knowledge spillover (Perri *et al.*, 2013).

Although apparently contrasting, the above-mentioned perspectives are complementary, and can provide a clearer understanding of a subsidiary's needs, in terms of the management of its knowledge assets, only if considered jointly. Support for this statement is provided by the recent work by De Faria & Sofka (2010), who find that subsidiaries adapt their knowledge protection strategies to both their own characteristics and host-country challenges and opportunities. We extend this stream of research by analyzing how the way subsidiaries manage such challenges and opportunities affects the extent of knowledge outflows they generate within the local context.

We posit that subsidiaries are subject to two different *stimuli* emerging from the host location: a *need for knowledge creation*, which arises from the willingness to benefit from the learning opportunities embedded in the external environment, and a *need for knowledge protection*, which derives from the urge to safeguard their competitive knowledge from the risk of local dissemination. The tension between these two needs will affect subsidiaries' choices in terms of knowledge management, thus influencing the extent of knowledge outflows generated in the host location. This framework is consistent with recent knowledge-based research (Arikan, 2009), which highlights that firms have two knowledge imperatives: to 1) "*secure access to all the knowledge it needs to prolong its value creation activities*", thus sourcing knowledge inputs from external networks to which it belongs; and to 2) "*exploit all the bodies of knowledge it possesses to the fullest*", thus appropriating of all the rents its knowledge generates.

In the following section, we elaborate on the concept of the *tension between knowledge creation and knowledge protection*, and try to demonstrate that subsidiaries' choices in terms of knowledge exchange relationships and knowledge protection affect the extent of knowledge outflows to the host location.

3. HYPOTHESES

3.1 Local knowledge outflows and the need for knowledge creation: subsidiaries' external focus in knowledge sourcing

Knowledge creation is a complex activity, which firms can hardly carry out in isolation. Relying just on the resources residing within a firm's organizational boundaries may not always be sufficient to renew a firm's knowledge endowment. In order to feed their knowledge production process, firms need to acquire knowledge from external sources and recombine them with internal resources (Von Hippel, 1988; Lundvall, 1992; Veugelers, 1997; Chesbrough, 2004; Laursen & Salter, 2006).

Local firms are an important source of knowledge for foreign subsidiaries. In a departure from the traditional view of the host-country as a mere option to create new markets or to obtain cheap resources, the "*learning-oriented FDI*" perspective has increasingly provided evidence about the knowledge opportunities offered by host regions (Cantwell, 1989). Literature has demonstrated that sector-specific knowledge develops in geographically concentrated areas (Marshall, 1920; Porter, 1990), and that countries follow different patterns of industrial specialization (Patel & Pavitt, 1991). Subsidiaries that access local sources of expertise absorb knowledge that may be highly beneficial, since it's often complementary, or at least different (hence, non-redundant), to that of the MNC (Singh, 2008). An abundance of studies demonstrates that subsidiaries extensively source knowledge from host regions (Almeida, 1996; Frost, 2001; Singh; 2007), and that this allows them to gain competence-creating mandates and power (Cantwell, 1989, 1995; Cantwell & Janne, 1999),

and to increase the quantity and the quality of their innovation (Almeida & Phene, 2004; Phene & Almeida, 2008).

However, acquiring knowledge from the external environment is not an immediate consequence of a subsidiary's localization in a foreign country. Localized knowledge flows through "*the establishment of interfirm (and interpersonal) linkages between firms in a region*" (Almeida & Phene, 2004, p. 849). In order to exchange resources and share unique knowledge, firms must involve in tight and repeated interactions that stimulate the creation of social networks and trust (Rogers & Larsen, 1984). When this happens, firms learn to benefit from each other, since they develop common cognitive models and collaborative attitudes; in addition, they may engage in processes of joint problem solving and information sharing, useful for their innovative activities (Gulati, 1995).

In the specific case of foreign firms, the access to localized sources of expertise may require them to build a *reputation for cooperation*, which allows subsidiaries that share their technology with local firms to become embedded in the domestic knowledge network. As a consequence, subsidiary managers might wish to involve into *reciprocal relationships* with host-country firms and accept to disclose some of their knowledge, if they expect to gain a greater local integration that facilitates the acquisition of relevant knowledge.

Social theory has demonstrated that this reciprocity mechanism is vital to the exchange of resources (Gouldner, 1960; Williamson, 1993): as a case in point, Saxenian (1994) reports the importance of knowledge sharing between firms for the dynamism and the success of the Silicon Valley region. Building on these findings, Business Network literature has highlighted the advantages firms can reap from stable and reciprocal relationships (Håkansson & Snehota, 1989; Johanson & Mattsson, 1992). Similarly, Kachra & White (2008) elaborate on the role of the self-interested "process of giving and getting" in the transfer of know-how between scientists. In sum, firms may deliberately engage in knowledge trading if the cost of giving away pieces of their knowledge is offset when the receiver returns the favor (Eapen, 2012).

We posit that subsidiaries that are interested in gaining access to the external sources of knowledge, and – as a consequence – have a *need for knowledge creation*, might find useful to demonstrate their willingness to reciprocate, thus accepting the leakage of some of their knowledge within the host location. We define the *external focus in knowledge sourcing* as a subsidiary's ability to absorb knowledge from the external environment, and to use this knowledge for further innovation. We expect that an external focus in knowledge sourcing is associated with reciprocity mechanisms, since subsidiaries that absorb knowledge from the outside are also expected to contribute to the knowledge network in which they are embedded, thus generating a higher extent of knowledge outflows:

Hypothesis 1: *There is a positive relationship between a subsidiary's external focus in knowledge sourcing and the extent of knowledge outflows to local firms.*

3.2 Local knowledge outflows and the need for knowledge protection: the value of subsidiaries' knowledge

A well-established stream of literature suggests that innovation in multinational subsidiaries is a peculiar process, since they are simultaneously embedded in two different knowledge contexts: (1) the *internal* multinational firm network, composed of the headquarters and other subsidiaries; (2) the *external* set of host country firms (Almeida & Phene, 2004). The opportunity to absorb knowledge from both these networks is nontrivial for subsidiaries' innovative output and creative processes. Traditional IB literature suggests that MNCs are highly effective in managing and leveraging their knowledge resources within their internationally distributed network, which makes their knowledge endowment especially rich and advanced (Bartlett & Ghoshal, 1989; Kogut & Zander, 1993; Hedlund, 1994; Birkinshaw, 1997; Frost *et al.*, 2002). Subsidiaries that are able to draw on MNCs' knowledge assets and to exploit the geographically distributed learning opportunities they are exposed to develop highly valuable knowledge. In turn, their local competitiveness is highly reliant on such "superior" knowledge. Moreover, they become extremely

attractive for local actors (Håkansson & Nobel, 2001), especially if the latter are strictly domestic, and hence do not have the chance to overcome the local search as multi-location firms do.

Resource-based theory suggests that, in order to serve as a means to pursue the firm's competitive advantage, resources must have some particular characteristics: among others, they must be rare and difficult to imitate (Barney, 1991; Dyer & Singh, 1998). In fact, when they diffuse to competitors and become replicable, they lose their strategic value.

According to the Knowledge-based Theory of the Firm (Grant, 1996), knowledge assets are a firm's most important resources and the primary sources of their rents. As a consequence, "*firms have every reason to prevent others from accessing a valuable body of knowledge they possess so that the knowledge remains rare and a source of competitive advantage*" (Arikan, 2009). Based on this line of reasoning, we expect that subsidiaries might not be willing to share their valuable knowledge with local firms. Subsidiaries' incentive to protect their knowledge from external appropriation increases with the value of such knowledge. In fact, the higher the knowledge value, the higher the loss associated with its diffusion. We conclude that increasing levels of knowledge value activate subsidiaries' *need for knowledge protection*. In turn, a higher knowledge protection will result in a lower extent of subsidiaries' knowledge outflows to local firms:

Hypothesis 2: *There is a negative relationship between the value of a subsidiary's knowledge and the extent of knowledge outflows to local firms.*

3.3 Local knowledge outflows and the tension between knowledge creation and knowledge protection

In presence of a need for knowledge creation, subsidiaries will seek to involve into reciprocal exchange relationships to the aim of absorbing beneficial knowledge from the external environment. Although subsidiaries may accept some knowledge leakage if they expect to gain access to local sources of expertise and technology, such "tolerant" attitude might not necessarily apply to any situation. When subsidiaries are the repository of valuable knowledge, they might be

expected to look at the reciprocity mechanisms stemming from an external focus in knowledge sourcing with reluctance, since the diffusion of their knowledge could be highly detrimental for their competitive advantage. Literature suggests that – although the source of relevant resources - knowledge-based interactions can be risky for a firm’s knowledge appropriation, and may endanger its competitive standing (Arikan, 2009). We suggest that the value of a subsidiary’s knowledge acts as a moderator of the reciprocity in knowledge exchanges arising from an external focus in knowledge sourcing.

Previous literature has highlighted that the technological heterogeneity of multinational firms affects their location choices (Shaver & Flyer, 2000, Alcacer & Chung, 2007). While lagging MNCs tend to agglomerate in clusters of related industrial activities, where the inward spillover (i.e., the knowledge inflows) is higher than the knowledge outflows - leading MNCs avoid highly concentrated locations, where they have much to lose and very little to learn. We argue that a similar mechanism applies to subsidiaries, and to their knowledge exchange strategies in the host regions. Specifically, we propose that subsidiaries that possess highly valuable knowledge are less willing to engage in reciprocal relationships (that might act as a channel for knowledge outflows) with local firms, since their need for knowledge protection is higher than their need for knowledge creation. In fact, as they already enjoy high levels of knowledge value, they expect to lose more than they can gain from the interaction with the local knowledge network. In such cases, even in presence of an external focus in knowledge sourcing, subsidiaries will seek to moderate reciprocal knowledge exchanges and increase their protective barriers, thus reducing the extent of knowledge that diffuses in the host location.

Summarizing this reasoning, we hypothesize that – in presence of an external focus in knowledge sourcing - the value of a subsidiary’s knowledge emphasizes the need for knowledge protection and moderates the effects of reciprocity in knowledge exchanges:

Hypothesis 3: *The value of a subsidiary's knowledge stock negatively moderates the relationship between the external focus in knowledge sourcing and the extent of knowledge outflows to local firms.*

4. DATA AND METHODS

4.1 Data

We test our hypotheses on a sample of US subsidiaries of European and Asian firms from the semiconductor industry. This is an appropriate empirical setting since it is one of the most technology intensive industries. Hence, profiting from external knowledge inflows while preventing the outflow of proprietary technology to competitors is a central issue for agents affiliated to this industry.

In this paper, we use patent citation data to measure the knowledge outflows generated by multinational subsidiaries in their host locations, and to develop measure of *subsidiaries' focus in knowledge sourcing* and *the value of subsidiaries' knowledge stock*. The advantages of using patent citation data to analyze the knowledge outflow phenomenon stem from the extensive information provided by patent documents, which includes the geographic location of both the inventor and the “owner” of the innovation, as well as its time and technology. Thanks to this information, patents allow to pinpoint the locus of the innovative activity, the organization to which the patent is assigned, and the temporal and technological features of the invention. In addition, patent documents report a list of citations to other patents which is useful to identify the technological antecedents to the particular innovation (Almeida, 1996), and whose inclusion is mandatory in the U.S. patent system.

As literature has widely documented, the use of patent citation data to investigate knowledge flows encompasses some potential limitations. First, patents represent by definition the *codified* part of technology and do not allow capturing the transfer of tacit knowledge. This generates a potential systematic under-estimation of the knowledge flow phenomenon. However, this problem is

partially mitigated by the fact that codified knowledge and tacit knowledge have been found to be correlated and complementary (Mowery, Oxley, & Silverman, 1996). An additional issue deals with examiner-added citations: in fact, not all citations contained in the patent document are spontaneously indicated by the inventor. Notwithstanding this limitation, empirical analysis of spillovers has long recognized the effectiveness of the citation measure (Jaffe *et al.*, 1993; Fogarty *et al.*, 2000; Branstetter, 2006), and leaves rather confident regarding its general significance. More broadly, recent theoretical research on inter-firm knowledge spillovers has recalled the importance of patent citation data as resources for spillover scholars to proxy their phenomenon of interest (Pacheco-de-Almeida & Zemsky, 2012)

To create our sample, we followed the procedure used by Almeida & Phene (2004) & Phene and Almeida (2008). We considered 11 European and Asian semiconductor MNCs among the sales leaders in year 2005. This list of firms was compiled using information from Gartner Dataquest and Osiris. For this set of MNCs, we identified every U.S. subsidiary engaged in innovation between 1983 and 2005¹. Our final sample is composed of 29 subsidiaries, observed over a 23-years period: hence, the unit of analysis is a subsidiary-year. The total number of observation in our sample should be 29 (the number of subsidiaries) multiplied by 23 (the number of years of observation). However, not all subsidiaries were observed throughout the whole period, since some of them only began patenting after 1983; moreover, due to the use of lags into our model, we dropped the first observation for each subsidiary. As a result, the actual size of our sample was 407. Patent data were obtained from an on-line database supplied by Derwent Inc., as well as from the U.S.P.T.O. Firm level data were obtained from Osiris.

¹ This means that, in order to be included into our sample, a U.S. subsidiary had to have registered for at least one semiconductor patent during the considered period. Moreover, we checked for the existence of the subsidiary since its establishment until the end of our period of observation.

4.2 Measures

4.2.1 *Dependent variable*

Knowledge Outflows to Local Firms As most of the studies about knowledge spillovers and knowledge flows, the dependent variable used in this paper stems from the geographic information contained on citations listed by a U.S. subsidiary's patent. Specifically, to capture the knowledge outflows from MNCs' subsidiaries to local firms, our dependent variable is defined as the number of (forward) citations made to a subsidiary's patent portfolio² in year t by the universe of local-invented patents applied for in year t.

In order to select the *local* citations relevant to the purpose of the analysis, the characterization of the correct sub-national geographic unit of analysis is crucial. Following recent trends in IB literature (Tallman & Phene, 2007; Zhao & Islam, 2006), in this study, we chose to use a more fine-grained option than that of the State, opting for the "Metropolitan Statistical Area" (MSA), as identified by the United States Office of Management and Budget³ (OMB). This choice is justified by the observation that many of the relevant U.S. semiconductor technology clusters span more than one state (e.g., New York - New Jersey – Connecticut tri-state area), and some states host more than one cluster (e.g., California).

4.2.2. *Independent variables*

External Focus in Knowledge Sourcing It is difficult to directly observe the focus of firms' knowledge sourcing. Therefore, in order to proxy a subsidiary's external focus in knowledge

² To identify a subsidiary's patent portfolio, we analyzed the patent assignee name (typically, the name of the MNC, like Sony or Samsung), and the address of the inventor (which had to be located within the boundaries of the Metropolitan Statistical Area where the subsidiary itself was established). The patent application date of successfully registered patents was used as the year of innovation. Only semiconductor patents were chosen as part of the subsidiary's patent portfolio, based on Derwent's technological classification. Hence, we selected only patents belonging to the first four Derwent patent classes included in the section "Semiconductors and Electronic Circuitry" (Alcacer & Zhao, 2011): U11 (semiconductor materials and processes), U12 (discrete devices), U13 (integrated circuits) and U14 (memories, film and hybrid circuits).

³ According to the U.S. Census Bureau, a Metropolitan Statistical Area is "a geographic entity, defined by the Federal OMB for use by Federal statistical agencies, based on the concept of a core area with a large population nucleus, plus adjacent communities having a high degree of economic and social integration with that core".

sourcing, we will measure the outcomes of such focus, as represented by citations data. Following Frost (2001), we assume that the attitude of subsidiaries to innovate by building directly upon different sources of knowledge may be inferred through the analysis of the pattern of citations referenced by a particular subsidiary patent. A similar framework has been used by Almeida & Phene (2004), to measure the “subsidiary focus” in knowledge sourcing: according to the authors, a large numbers of self-citations reflect “*an inward looking focus and an emphasis on exploitation*”, while a small number of self-cites suggests “*an external orientation and a focus on exploration*” (Almeida & Phene, 2004). Similarly, Phene & Almeida (2008) in their study about the role of knowledge assimilation and subsidiaries capabilities for subsidiaries’ innovative processes suggest that “*cited patents identify the technological antecedents of the innovation, and reflect the knowledge assimilated to create innovation*” (Phene & Almeida, 2008): therefore, analysing cited patents, we can infer what are the knowledge bodies on which subsidiaries have build to create new knowledge. Along with this reasoning, we assume that the greater the number of citations (referenced by a subsidiary patent) to patents generated by external organizations, the greater the subsidiary external focus in knowledge sourcing⁴. Hence, following Almeida & Phene (2004)⁵, we calculate the external focus in knowledge sourcing as the total number of (backward) citations a subsidiary’s patent portfolio has referenced to patents that were assigned to a firm other than the MNC in year t-1⁶.

Value of a Subsidiary’s Knowledge Stock Most of the studies which use patent data proxy the value of innovation with the number of forward citations a patent receives (Trajtenberg, 1990; Gittelman & Kogut, 2003; Singh, 2008). When patents are extensively cited, it means that the knowledge they

⁴ Notice that subsidiaries often tend to cite patents that belong to the headquarters, to other sister units or to self-cite their own patents. In fact, MNCs are known for their ability to distribute and share the knowledge produced in different parts of its international organization within its whole global network. Such a subsidiary’s behavior would signal an internal focus in knowledge sourcing. On the other hand, a subsidiary that cites patents belonging to organizations others than the MNC distinguishes itself for its ability to draw on knowledge bodies that are external to the MNC’s organization.

⁵ In this paper, the authors measure the “subsidiary focus” in knowledge sourcing as the total number of self backward citation the subsidiary’s patent portfolio has referenced to patents assigned to the subsidiary itself, in year t-1.

⁶ This is because we expect a lag between the subsidiary’s external focus in knowledge sourcing and our dependent variable.

embody has been used to realize several further innovations. Therefore, it is supposed to be relevant and productive. Hall *et al.* (2005) find that firms' patent citations are significantly correlated with their market value. As a consequence, highly cited patents should correspond to relevant technological innovations (Gittelman & Kogut, 2003).

To build our measure of the value of a subsidiary's knowledge stock, we embrace this perspective and consider the average number of citations that a subsidiary's patent portfolio has received up to year $t-1$ ⁷ (total number of citation/scale of the subsidiary's patent portfolio). We excluded from this count the self-citations from the MNC (both from the subsidiary itself, and from any other tie of the MNC's internal network), in order to have an objective evaluation of the value that external agents recognize to the subsidiary's knowledge (Phene & Almeida, 2008).

This provides us with a measure of the value of a subsidiary's knowledge stock in terms of “*average citations received on a per-patent basis for the subsidiary patent portfolio*” (Phene & Almeida, 2008; p.908).

4.2.3 Controls

A series of firm, patent portfolio and locational characteristics have been applied as control variables in our model.

First, since we expect that the number of citations a subsidiary receives depends on the number of patents it owns, we controlled for the size of a subsidiary's patent portfolio in year t , a count-based measure of the patents a subsidiary has successfully applied for up to year t (*Portfolio Size*).

The age of the patent portfolio is a variable needed to control for heterogeneity in the “citedness” of different foreign subsidiaries, which is driven by differences in the age distribution of their patent stocks (Branstetter, 2006). Jaffe *et al.* (2000) have found that the knowledge contained in patents needs time to diffuse. Therefore, patent citations tend to increase over time at the beginning of the cited patent lifetime, and to decrease over longer periods, as the innovations they represent become

⁷ Also in this case, we expect a lag between the quality of innovation and our dependent variable.

dated⁸ (Branstetter, 2006). To account for this effect, for each year and each subsidiary, we included an index calculated (*Portfolio Age*) as the number of patents, in a subsidiary's patent portfolio, that are at this peak "citing age", divided by the residual number of a subsidiary's patents.

Moreover, to assure that differences in the extent of knowledge outflows are not driven by the degree of local integration of the foreign subsidiaries, we added a measure that accounts for the number of years in which the subsidiary has been located in the U.S. For foreign subsidiaries to be integrated within the host-location, both formal and informal linkages must be created and nourished. These linkages constitute an easy channel through which knowledge may flow to host-country firms. However, for these channels to develop, it takes a long time (Criscuolo *et al.*, 2002), since subsidiaries must embed in the local context. Controlling for the subsidiary age, we seek to isolate this effect from the ones that are the main objects of this research. We build this variable as the number of years between year t and the year of the subsidiary's first patent application (*Subsidiary Age*).

The headquarters' technological assets have been traditionally considered as a major determinant of the local knowledge spillovers (Caves, 1974). Subsidiaries that are part of highly innovative multinational firms are believed to deliver a greater extent of knowledge outflows to the host location. In particular, the knowledge accumulated at the headquarters level has always been identified as main source of the local spillover effect. To control for such HQ-level characteristic, we introduce a measure of the "*Headquarters' Knowledge Stock*", given by the (log of the) total number of semiconductor patents applied for by the headquarters (whose inventor location is the MNC's home country), up to year $t-1$.

Localized knowledge flows are more likely to happen in clusters of concentrated technological activities (Jaffe & Trajtenberg, 1998). To account for this, we also included a measure of "*Cluster*

⁸ Empirical evidence shows that a patent usually receives its highest amount of citations 4-6 years after its granting (Branstetter, 2006). However, since the semiconductor industry is a fast-changing technological environment, and semiconductor products have a duration of a product life cycle of 5 year on average (Almeida and Phene, 2008), we considered the peak age of semiconductor patents as being comprised between 3-5 years.

Importance”, given by the (log of the) total number of semiconductor patents applied for by inventors located in the focal MSA in year t .

The number of citations a subsidiary’s patent portfolio receives will also tend to increase with the general amount of potentially citing local patents applied for in year t , but this effect will be absorbed into the time dummies. In fact, since our research analyses subsidiaries over a number of years, we added year dummies in our model to account for possible effects of serial correlation.

4.3 Methods

The first econometrical concern about empirical analyses involving patents and patent citations refers to the count nature of the dependent variable (Hausman *et al.*, 1984). Literature suggests dealing with this type of data by using a Poisson model. However, such model is based on the assumption of no heterogeneity in the sample. In fact, unobserved heterogeneity may lead to a case of “over-dispersion”, thus generating underestimation of standard errors and an inflation of significance levels.

When performing a Poisson estimation on our full model, the results showed a high and significant value of chi-square (chi-square = 3491.65, with a p-value of 0.0000), which signals the presence of over-dispersion, and advises against the use of the Poisson specification. We dealt with this problem by using an econometric model whose design corrects for the presence of over-dispersion: the negative binomial regression model, developed by Hausman *et al.* (1984).

Since we have panel data including repeated observations of our sample of subsidiaries, there might be unaccounted subsidiary effects that are fixed in time or vary randomly. In order to establish whether to use fixed-effects or random-effects specifications, we performed the Hausman test (1978), and we found significant differences between the coefficients. Therefore, we rejected the random effects specification, and used fixed effects.

5. FINDINGS AND DISCUSSION

Table 1 presents the descriptive statistics and bivariate correlations among all variables included in our model. The high value of the correlation coefficients between the External Focus in Knowledge Sourcing and the Portfolio Size (0.693) requires attention, and will be object of further investigation. Potential problems of multicollinearity could also emerge from the inclusion of our interaction variable. To account for this issue, we followed the standard procedure (Aiken & West, 1991) and centered the interacting term to reduce collinearity.

The results of our negative binomial models with fixed effects are presented in Table 2.

We first test a baseline model (Model 1) including all our controls variables. The results point to the importance of the Headquarters knowledge stock for the local knowledge outflows phenomenon, and confirm traditional beliefs on the importance of the MNCs' technological development for the FDI-mediated spillover effect (Caves, 1974). Predictably, also the variables "Portfolio Age" and "Subsidiary Age" were positive and significant.

Model 2 presents our findings on the effect of subsidiaries' External Focus in Knowledge Sourcing on the extent of knowledge outflows to local firms. We find strong support for Hypothesis 1 regarding the reciprocity in knowledge exchange mechanism. The coefficient of our External Focus in Knowledge Sourcing variable is positive (+0.001) and highly significant ($p < 0.01$), and the Wald statistic increases from 284.73 to 312.84. Our result shows that the stronger a subsidiary's *need for knowledge creation* (and, therefore, the higher is the extent of knowledge it absorbs from external sources, e.g. the host location), the higher will be its contribution to the local knowledge network, in terms of knowledge outflows. Indeed, in order to gain and maintain the access to the host knowledge base, the subsidiary will need to reciprocate the knowledge acquired externally, accepting the leakage of some of its proprietary technology.

Model 3 accounts for the effects of the subsidiaries' *need for knowledge protection*. Hypothesis 2 is supported, as we can see from the negative (-0.115) and significant ($p < 0.01$) coefficient of the Knowledge "Value" term. All else equal, subsidiaries that are able to produce highly valuable

knowledge are less likely to share it with their host location, since they find it crucial to maintain the control on it. As a consequence, they generate lower levels of knowledge outflows to local firms.

Model 4 presents the results of the full model. The inclusion of the interaction term between a subsidiary's External Focus in Knowledge Sourcing and the Value of its knowledge leads to an increase in the overall fit of the model, with the Wald statistic at 367.93. While the signs of the interacting terms remain unchanged, the interacting coefficient turns out to be negative (-0.001) and significant ($p < 0.01$), supporting our Hypothesis 3. In presence of high Knowledge Value, the relationship between the External Focus in Knowledge Sourcing and the extent of knowledge outflows to local firms is negatively moderated. This finding seems to suggest that, when subsidiaries' knowledge is strongly valuable, subsidiaries seek to enforce their knowledge protection strategies, thus restraining the reciprocity mechanisms associated with the need for knowledge creation. This leads to a lower extent of local knowledge outflows⁹. In fact, in presence of high Knowledge Value, the need for knowledge protection is more urgent than the need for knowledge creation.

5.1 Conclusions and Implications

Our study investigates the trade-off between the need for knowledge creation and the need for knowledge protection, and how it affects the extent of knowledge outflows subsidiaries generate within their host regions. Empirical findings confirm our hypotheses that subsidiaries that source more from the external knowledge network are also more likely to contribute to it, due to the mechanism of reciprocity in knowledge exchanges. The willingness to gain access to foreign pockets of expertise and complementary knowledge drives subsidiaries to tolerate the leakage of

⁹ Due to the high correlation between some of our variables, we performed several sensitivity analyses to ensure the robustness of our results. More specifically, we dealt with the high value of the correlation coefficient between the External Focus in Knowledge Sourcing and the Portfolio Size (0.693). We ran our full model regressions without the Portfolio Size variable: our results did not change, and the External Focus in Knowledge Sourcing maintained its sign and significance.

part of their own knowledge to local firms. This is done with the ultimate aim to build up the trust needed to facilitate local knowledge inflows. However, as the value of subsidiaries' knowledge increases, the level of knowledge outflows diminishes, suggesting that subsidiaries tend to protect their assets from external appropriation more, when the competitive value of such assets is very high. Interestingly, our results also show that the presence of high knowledge quality lowers the effects of reciprocity in knowledge exchanges, since its interaction with the subsidiaries' External Focus in Knowledge Sourcing is negatively associated with the level of local knowledge outflows. Based on our theoretical reasoning, we believe that such finding can be explained by the tension between the need for knowledge creation and the need for knowledge protection: when the value of a subsidiary's knowledge is very high, the pressure to protect its assets is much more urgent than the need to build reciprocal knowledge linkages that could foster the creation of new knowledge. Specifically, subsidiaries with high knowledge value that source external knowledge seek to moderate mechanisms of knowledge reciprocity, and to protect their knowledge more extensively. This is due to the greater potential danger associated with the dissemination of their knowledge in the host location. These results are consistent with a recent theoretical study on inter-firm knowledge exchanges within a cluster, claiming that *"knowledge interactions are plagued by opportunism and appropriability problems. Solutions to these problems lie in the development of trust and norms of cooperation within the cluster. Yet competitive challenges make the development of cooperative norms highly difficult while at the same time creating numerous reasons to break them once they are established"* (Arikan, 2009).

The study offers two main contributions. In the first place, it adds to the literature on the firm-level antecedents of FDI-mediated knowledge diffusion (Chung, 2001; Branstetter, 2006; Marin & Bell, 2006; Driffield & Love, 2007), which so far has focused on the structural profile of the MNCs and the subsidiaries, while leaving aside the issue of the subsidiary's knowledge strategies. Building on recent insights on the active role of subsidiaries in the generation (Cantwell & Mudambi, 2005; Phene & Almeida, 2008) and protection (De Faria & Sofka, 2010) of knowledge in MNCs, we

investigate how a subsidiary's management of its knowledge assets influences the extent of knowledge outflows generated locally. Furthermore, by putting unprecedented emphasis on the social mechanisms underlying the process of knowledge diffusion from MNCs' foreign subsidiaries to local firms, we offer a much more socialized view of the FDI-mediated knowledge outflows phenomenon. This is in line with recent theoretical research highlighting the pervasive role social norms play in FDI spillover related issues (Eapen, 2012).

More broadly, this paper contributes to general IB literature on the relationship between subsidiaries and their host regions. Overcoming traditional perspectives that have mainly looked at the foreign location *either* as an opportunity *or* as a threat for MNC subsidiaries' competitiveness, we show that both the roles are possible, if we explicitly account for the subsidiaries' needs in term of knowledge creation and knowledge protection.

Though this paper provides interesting insights on the firm-level antecedents of FDI local knowledge outflows, the study bears some limitations. First, our sample is limited to US-based semiconductor subsidiaries. Moreover, we acknowledge that the choice of the firms analyzed in the study was driven by data availability. Therefore our sample is a convenient sample, and our findings might not hold for the full population of semiconductor firms. In future research, we plan to provide further support to our findings by extending the focus of our analysis to subsidiaries located in other host countries, as well as belonging to other high-tech sectors. Second, we measure most of our variables through the use of patents and patent citations. We recognize that analyzing the information stemming from these sources is not the most accurate way to infer firms' capabilities or strategic behaviors. However, this approach is not new to the empirical research on subsidiary knowledge management, given the scant sources of secondary data available (Almeida & Phene, 2004; Phene & Almeida, 2008). In future studies, we propose to use a survey methodology to better capture the phenomenon of analysis, and to complement our results. Finally, our study offers only a description of the link between the patterns of local knowledge outflows and the subsidiary-level antecedents considered. We draw some assumptions regarding mechanisms of

reciprocity that explain the effect of subsidiaries' External Focus in Knowledge Sourcing on the local knowledge outflows, as well as regarding the protective attitudes that drive subsidiaries with high knowledge value to limit local knowledge diffusion. However, we are not able to indicate the actual arrangements subsidiaries use to loosen or restrict the flow of their knowledge in the host-region. Again, in future studies, we hope to focus on the concrete knowledge management measures subsidiaries carry out in order to optimize the interaction with the local knowledge network.

In terms of implications, this paper encompasses important insights for managers of both the subsidiaries and the local firms. Regarding the subsidiaries, most of prior research has looked at the phenomenon of knowledge outflows as a danger for firms, whose assets could be appropriated by competitors, thus losing their competitive value (Shaver & Flyer, 2000; Alcacer & Chung, 2007). In this study, we demonstrate how subsidiaries' managers may use their knowledge as "bargaining chips" in the relationships with the local partners, thus working "*on the social side of the exchange calculus*" (Kachra & White, 2008). In this case, allowing for the occurrence of knowledge outflows within the host location is just another competitive tool subsidiaries can use to gain access to the local knowledge network, thus acquiring the complementary resources they need to evolve. Of course, such strategy might become too dangerous in situations when the subsidiary knowledge value is very high. In these cases, subsidiaries' managers should rethink the decision to adopt reciprocity behaviors to tap into the local knowledge network. At the same time, they should invest more in the protection of their own knowledge resources, since they often constitute the real competitive asset that distinguishes them from local competitors.

Local firms' managers, on the other hand, should be aware that subsidiaries' "cooperative" behavior not necessarily signals a stable approach to the local knowledge network. Subsidiaries reciprocate to knowledge exchanges when this choice is consistent with the pursuit of their knowledge imperatives and with their need for knowledge creation, but they may turn to more opportunistic attitudes when sharing their resources within the local knowledge network implies a too high strategic loss.

The analysis also provides a major policy implication. In fact, when designing FDI-attraction strategies, policy makers should be aware that: (1) MNCs will likely share their knowledge with local firms mainly if they expect to gain something in return; (2) the most advanced subsidiaries, which own highly valuable knowledge and superior technology, are the ones contributing less to the local knowledge network, since they are likely to implement the strictest protection strategies to avoid external appropriation of their competitive assets. In conclusion, governments that aim to incentivize the localization of FDI in their countries should account for the possibility that the most technologically advanced subsidiaries might not be the best targets to attract, when aiming at fostering local firms' acquisition of MNCs' knowledge.

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Table 1. Correlation matrix

	1	2	3	4	5	6	7	8	9	10
1 Local_Know_Flows	1.000									
2 Know_Value	0.228	1.000								
3 External Focus	0.537	-0.005	1.000							
4 HQ_Know_Stock	0.129	0.388	0.063	1.000						
5 Cluster_Importance	0.331	0.290	0.077	0.184	1.000					
6 Sub_Age	0.480	0.599	0.262	0.427	0.408	1.000				
7 Ptf_Size	0.642	0.188	0.693	0.117	0.063	0.440	1.000			
8 Ptf_Age	0.083	-0.062	0.000	0.136	-0.021	0.023	0.013	1.000		
9 R&D_int	0.304	0.134	0.278	0.350	0.135	0.357	0.388	0.026	1.000	
10 Missing_R&D	-0.185	-0.207	-0.131	-0.436	-0.185	-0.248	-0.171	-0.039	-0.748	1.000
Mean	3.658	0.000	33.677	7.363	5.253	10.994	39.446	0.260	0.037	0.544
Std. Dev.	7.940	3.604	86.146	1.421	1.649	6.768	95.580	0.223	0.054	0.498
Min	0.000	-3.996	0.000	0.000	0.000	1.000	1.000	0.000	0.000	0.000
Max	58.000	19.004	853.000	9.181	7.842	31.000	660.000	1.000	0.210	1.000

Table 2. Subsidiary Knowledge Outflows: negative binomial regression with fixed effects

<i>Dependent Variable:</i>	<i>Baseline Model</i>	<i>Knowledge Creation Model</i>	<i>Knowledge Protection Model</i>	<i>Interaction Model</i>
<i>Local Knowledge Outflows</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 3</i>
<i>Independent Variables</i>				
Hp. 3: Ext_Focus_Value				-0.001*** (-4.11)
Hp. 2: Know_Value			-0.115*** (-3.04)	-0.094*** (-2.58)
Hp. 1: External_Focus		0.001*** (3.50)	0.001*** (2.58)	0.001** (2.00)
<i>Controls</i>				
HQ_Know_Stock	0.278* (1.69)	0.291* (1.79)	0.305* (1.89)	0.379** (2.23)
Cluster_Importance	0.246 (1.12)	0.166 (0.71)	0.029 (0.11)	-0.029 (-0.11)
Sub_Age	0.100*** (3.23)	0.093*** (2.93)	0.086** (2.55)	0.084** (2.45)
Ptf_Size	0.001 (1.24)	0.001 (0.74)	0.001 (0.81)	0.002** (2.29)
Ptf_Age	0.999*** (3.47)	1.019*** (3.60)	0.766*** (2.67)	0.644** (2.31)
R&D_int	0.766 (0.37)	1.125 (0.55)	-0.231 (-0.11)	-0.553 (-0.28)
Missing_R&D	0.512** (2.17)	0.642*** (2.77)	0.456* (1.93)	0.496** (2.18)
Year_Dummies	included	included	included	included
Const	-20.09 (-0.03)	-19.54 (-0.03)	-19.58 (-0.02)	-18.62 (-0.03)
Wald Statistic	284.73***	312.84***	330.75***	367.93***
<i>N</i>	407	407	393	393

- 1) Standard errors in parentheses.
- 2) * p<0.1, ** p<0.05, *** p<0.01.
- 3) All models include year dummies.