Management and Organization Review

Management and Organization Review 9:3, November 2013, 489–512
doi: 10.1111/more.12026

Do Foreign-owned Subsidiaries in China Follow a Distinctive Pattern of Technological Knowledge Sourcing?

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ABSTRACT This study investigates the China-located subsidiaries of foreign-owned multinational corporations (MNCs) for patterns of intra-firm and interorganizational technological knowledge accumulation. We analyze US patents attributed to those subsidiaries between 1996 and 2005 and argue that MNCs have recently tended toward open network structures, enabling subsidiaries in emerging markets to develop technological capabilities by searching for diversified inter-organizational knowledge sources beyond geographically local contexts to compensate for local limitations and deficiencies. Findings show that subsidiaries in China have gradually developed their technological capabilities through non-localized searches beyond their organizational, technological, and geographical boundaries. The study contributes to the literature on MNC organizational restructuring, subsidiary evolution, and subsidiary-level non-localized knowledge searches. The findings also have important implications for knowledge spillovers, MNC knowledge management, and government policies.

KEYWORDS China, MNC subsidiary, non-localized search, technological capability

外资企业是否在中国遵循特殊的科技能力发展道路?

摘要

本文研究外资跨国公司在中国通过内部及外部途径进行科技知识积累的模式。经过分析这些企业在美国专利局1996到2005年间的专利数据，我们认为跨国公司近年来向开放型网络结构的转变使这些公司在发展中国家的分公司能够克服内部及外部环境的不足，从而有机会发展科技能力。我们的研究结果表明跨国公司在中国的分公司通过非本地式知识积累已经逐渐开始具备科技能力。非本地式知识积累包括跨越地域的，跨越组织界限的，跨越科技界限的知识积累。因此，本文在以下领域有所贡献：跨国公司结构转型，分公司进化论，分公司非本地式知识积累。我们的研究结果在知识外溢，跨国公司知识管理和政府政策方面也有实际意义。

关键词：中国， 跨国公司分公司， 非本地式知识积累，科技能力

INTRODUCTION

Multinational corporations (MNCs) have evolved toward more open-structured interorganizational network relationships. Those more federative structures of intra-firm network relationships suggest that at least some large MNCs are increasingly integrating knowledge systems derived from internal and external sources (Andersson, Forsgren, & Holm, 2007; Cantwell, 2013; Ernst & Kim, 2002). Relatively closed, top-down, usually headquarter-controlled network structures tend to emphasize in-house technological development, whereas open network structures have wider nodes that create competence and generate competitive advantages (Almeida & Phene, 2004; Birkinshaw & Pedersen, 2009; Cantwell & Mudambi, 2005; Ghoshal & Bartlett, 1988; He & Wong, 2004). To develop capabilities and generate competitive advantages, geographically dispersed subsidiaries – MNC network nodes – may search beyond parent-owned sources and technological expertise (Bartlett & Ghoshal, 1986; Birkinshaw, Hood, & Jonsson, 1998); that is, they search for knowledge beyond the immediate organizational and technological boundaries, hence the searches are *non-localized* (Rosenkopf & Almeida, 2003; Rosenkopf & Nerkar, 2001).

Non-localized search effectiveness depends on the value of the knowledge absorbed from external environments (Cohen & Levinthal, 1990; Laursen & Salter, 2006; Phene & Almeida, 2008). In emerging markets, however, external environments lack advanced technological and managerial knowledge (Hitt, Li, & Worthington, 2005; Li, Chen, & Shapiro, 2010a; Li, Poppo, & Zhou, 2010b), and also have weak intellectual property regimes (Zhao, 2006). Thus, subsidiaries in emerging economies, when relying exclusively on host country external or international internal sources, are clearly limited in their ability to develop their technological capabilities, but might begin to overcome these limitations through non-localized searches.

We argue that when MNCs have more open network structures, their subsidiaries are less likely to confine their external searches to the immediate external environment and will be better able to search local and distant sources for diversified knowledge that can be combined with knowledge from within the MNC. Although researchers have largely studied technologically localized or non-localized searches (Cohen & Levinthal, 1990; Kogut & Zander, 1992; Rosenkopf & Nerkar, 2001; Stuart & Podolny, 1996) and geographically localized searches (Almeida, 1996; Jaffe, Trajtenberg, & Henderson, 1993) separately, we integrate them in this study, and extend the concept of non-localized searches for MNC subsidiaries in emerging markets by incorporating knowledge searches beyond organizational, technological, and geographical boundaries.

We support our argument by analyzing foreign-owned subsidiaries in China between 1996 and 2005 for their technological knowledge accumulation. This period represents the early development of foreign-owned subsidiaries in China

https://doi.org/10.1111/more.12026 Published online by Cambridge University Press

(People's Daily Online, 2010; The Ministry of Commerce of China, 2006) and generates two important considerations. First, economic transition often involves multiple stages characterized by changes and improvements in the economic and institutional environment (Kim, Kim, & Hoskisson, 2010; Steensma, Tihanyi, Lyles, & Dhanaraj, 2005). China is the largest and one of the most successful emerging economies (Luo, 2003). As foreign-owned subsidiaries in China accumulate technological capabilities over time, China's business environment, particularly the availability of external knowledge sources, has improved because of, for instance, knowledge spillovers from foreign-owned MNCs. This possibility of coevolution between the firm and its environment makes the study of early subsidiary capability development interesting because the subsidiary-level knowledge accumulation pattern may depend partly on the maturity of economic transition. A better understanding of subsidiary technological capability development in a more deficient and volatile environment characterized by early economic transition would have important theoretical and practical implications for MNCs and other developing countries that are striving to competitively modernize their economies.

Second, considering that capability development is path-dependent (Cohen & Levinthal, 1990; Nelson & Winter, 1982), an insight into subsidiaries' technological knowledge accumulation at an early stage of development is important for a better understanding of their later capability development and for explaining the trajectory of their future capability development. Yet much previous research on subsidiary capability development has focused on subsidiaries in mature industrialized countries, which vary significantly in terms of their age and development status. China during the study period provides an ideal background for studying MNC subsidiaries' early capability development. The trend toward globalization has led many MNCs to increasingly disperse their supply chain activities in developing countries, especially in some emerging markets (Dunning, Fujita, & Yakova, 2007). Meanwhile, emerging markets, such as China, are actively developing international connections to further open and advance their fast-growing economies (Alvarez & Cantwell, 2011; Hobday & Rush, 2007). In this context, although most foreign-owned research and development (R&D) subunits in China were established after the mid-1990s (The Ministry of Commerce of China, 2006), China's fast-growing economic environment has also accelerated the capability development of recently formed MNC subsidiaries. Between 1996 and 2005, China produced a coherent dataset for investigating early-stage capability development in subsidiaries, allowing us, at least as a starting point, to focus on the early technological capability development of foreign-owned subsidiaries in China to better understand subsidiary capability development in emerging markets.

With this study, we make three major contributions. First, studies of nonlocalized searches have focused on technologically distant knowledge searches across organizational boundaries (Rosenkopf & Nerkar, 2001; Stuart & Podolny,

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1996). We define *non-localized search* broadly as search efforts beyond a firm's immediate context, namely outside its organizational, technological, and geographical limits, and show that spanning all three boundaries is crucial for subsidiary technological capability development when the host environment is less technologically advanced. Second, subsidiaries in mature industrialized countries usually create technological knowledge by combining international intra-firm and local interorganizational knowledge (Andersson & Forsgren, 2000; Cantwell & Zhang, 2011; Frost, Birkinshaw, & Ensign, 2002), but foreign-owned subsidiaries in China more often combine international intra-firm and international interorganizational knowledge when generating new technological knowledge. This finding contributes to the subsidiary capability development literature by showing that when subsidiaries build on combinations of intra- and interorganizational knowledge sources, the sources might have quite different geographical origins, so the new knowledge is created in locally distinctive ways, especially in an emerging market with weaker institutional but fast-growing external environments. Finally, rather than studying the eventual performance outcomes of subsidiary capability development that are more readily ascertainable for MNC subsidiaries in mature industrialized countries, we focus on the structure or composition of technological knowledge development in foreign-owned subsidiaries in China. This new approach allows us to better capture the subtle beginnings of capability accumulation of foreign-owned subsidiaries in emerging markets. This approach also facilitates cross-country comparison in terms of the breadth of subsidiary capability development without being biased by different growth rates in subsidiary locations when comparing performance outcomes at subsidiary levels. Finally, the interaction between firms and their external environment is at the centre of an open innovation approach, so our findings about the relevance of subsidiary interorganizational knowledge sourcing also have important implications for potential knowledge spillover contributions to other co-located actors.

In the next section, we review the literature and develop hypotheses. In the third and fourth sections, we report the empirical settings and statistical results. In the final sections, we discuss the implications of our findings and draw conclusions.

THEORETICAL BACKGROUND AND HYPOTHESES

The conventional approach to MNCs has generally assumed that competitive advantages are essentially derived from home-country, headquarter-generated, in-house capabilities, representing relatively closed and top-down MNC network structures. However, as the organizational form has matured, restructuring has emerged, so that MNCs have steadily evolved as international business networks that incorporate and may often be driven by the MNC, but are not necessarily restricted to it; that is, they are moving toward more open and informal network

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structures (Andersson & Forsgren, 2000; Cantwell, 2013). As many MNCs restructure and decentralize, knowledge creation becomes more geographically dispersed within the firm, and subsidiaries become more critical for knowledge generation (Birkinshaw et al., 1998), sourcing knowledge from their own intra-MNC network and from local networks of other organizations in which they must be embedded to become independently locally creative (Andersson, 2003; Andersson, Forsgren, & Holm, 2002). While mature industrialized countries saw the earliest evolution of MNC subsidiaries toward overseas competence-creating activities, MNCs are turning to emerging market countries for high value-added activities in addition to their efficiency-seeking manufacturing faculties. For instance, by June 2004, the accumulated R&D investments of foreign-owned MNCs in China had reached approximately $4 billion (UN, 2005). By 2008, as many as 1,100 foreign-invested R&D centres were operating in China (Bruche, 2009).

Open and distributed MNC network structures offer subsidiaries in emerging markets opportunities to develop capabilities. The structures free MNCs from solely relying on in-house R&D, as occurs in relatively closed network structures. Open innovation strategies allow MNCs to draw on a wider range of external actors and sources for achieving and sustaining innovation (Chesbrough, 2003; Laursen & Salter, 2006). As new nodes in an MNC's competence-creating network, subsidiaries are allowed, and sometimes encouraged, to explore interorganizational knowledge sources. Yet subsidiaries have a short period of development thus far in emerging markets, so they have not yet accumulated internal bases of specialized technological knowledge strong enough for MNCs to recognize them as centres of excellence (Frost et al., 2002). Yet, the coopetition environment within large MNCs (Andersson et al., 2007; Luo, 2005; Mudambi & Navarra, 2004) suggests that subsidiaries in emerging markets, as latecomers, are motivated to quickly catch up with their sister subsidiaries in mature industrialized countries to maintain and improve their strategic status within the MNC. Although overseas subsidiaries look to the parent company as a reliable intra-firm technological knowledge source, relying exclusively on the parent company limits their capacity to identify new technological opportunities and to develop their own independent specialized knowledge base (Andersson & Forsgren, 2000; Bartlett & Ghoshal, 1986; Birkinshaw, 1997; Kogut & Zander, 1992). Moreover, given the uncertain and volatile business environment in emerging markets (Hoskisson, Eden, Lau, & Wright, 2000; Luo, 2003), knowledge from intra-MNC sources may be inadequate for navigating and taking advantage of a fast-growing and radically transforming economy. In this context, diversified knowledge from interorganizational sources may offer critical complementarities with knowledge that subsidiaries can obtain from within the MNC. For instance, while possessing relatively advanced technological knowledge, foreign entrants in emerging markets often seek opportunities to gain local institutional and marketing knowledge from domestic firms (Hitt et al., 2005; Li et al., 2010a,b).

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Although inter-organizational knowledge sourcing is usually conducted in a geographically local context, emerging markets lack advanced technological knowledge, which creates a problem for subsidiary capability development, particularly technological capability development (Liu, Chen, & Kittilaksanawong, 2013). In this context, the MNC's geographically and spatially distributed structure plays an important role for subsidiary technological capability development. The technological profiles of the MNC's geographically dispersed competence-creating nodes first indicate the technological strength of their host locations. To compensate for deficiencies in their local external environment, knowledge exchange across the MNC's spatial organization helps subsidiaries in emerging markets identify or become aware of diversified knowledge sources in international locations. In other words, although subsidiaries' external networks are often geographically localized, they may also be international (Forsgren, Holm, & Johanson, 2005; Rosenkopf & Almeida, 2003). The subsidiary's need to maintain local responsiveness may be considered as being local in a functional rather than, or as well as, a geographical sense (Cantwell, 2013).

In sum, at a corporate level MNCs can overcome 'unbalanced' national diamonds by acquiring complementary capabilities across borders (Asmussen, Pedersen, & Dhanaraj, 2009). More spatially open network structures also enable individual subsidiaries to enhance their internal knowledge and their host environment by exploring diversified inter-organizational knowledge sources beyond the local environment. To facilitate and further open up fast-growing economies, emerging markets are actively developing international connections (Alvarez & Cantwell, 2011; Hobday & Rush, 2007). In this sense, MNC subsidiaries in emerging markets must internationalize their knowledge sourcing not only to catch up with technological capabilities, but also to fit into the overall catch-up strategies of emerging market countries.

Capability development is a cumulative process (Frost et al., 2002; Nelson & Winter, 1982), so MNC subsidiaries in emerging markets may have not yet reached the point of capturing their capability accumulation by more common indicators such as referring to the subsidiary's innovative or market performance (Phene & Almeida, 2003, 2008), the subsidiary's importance to the MNC as a knowledge provider (Andersson et al., 2002; Rugman & Verbeke, 2001), or the change of subsidiary charter so that the parent company acknowledges it as a centre of excellence (Birkinshaw & Hood, 1998; Frost et al., 2002). Because subsidiary evolution seems to depend most on internal and external knowledge network interactions (Birkinshaw & Pedersen, 2009), the knowledge sources tend to shift as a subsidiary evolves. A closer look at the structure of knowledge accumulation, before MNC subsidiaries in emerging markets accumulate sufficient capabilities to substantially evolve, offers a vital means of evaluating subsidiary capability development and predicting its future trajectory. In the next section, we develop hypotheses related to the technological knowledge structure of foreign-owned subsidiaries in China.

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Hypotheses Development

Competence-building methods (Rugman & Verbeke, 2001) suggest that acquiring external knowledge – inter-organizational knowledge sourcing – plays an increasingly important role as subsidiaries develop capabilities, broaden the technological breadth of their innovative activity (Phene & Almeida, 2003), and improve their technological innovations (Phene & Almeida, 2008). In particular, as subsidiaries gradually incorporate external knowledge from technological fields distinct from most internal knowledge, new technological knowledge is generated. Moreover, as subsidiaries develop capabilities, they gradually loosen their dependency on the parent's expertise. In new technological knowledge generation, specialized knowledge (usually core technologies) is typically complemented by external knowledge in peripheral fields (non-core technologies) that provide ideas for new combinations (Kogut & Zander, 1992). Consequently, subsidiary capability development increasingly relies on non-localized search.

In non-localized search, organizational boundary spanning is often also associated with technological boundary spanning. A study of patenting activities in optical disk technology found that exploration spanning organizational and technological boundaries – non-localized search – highly impacts subsequent technological development (Rosenkopf & Nerkar, 2001). Similarly, Japanese semiconductor firms used inter-firm alliances to gradually incorporate partner knowledge into technologically distant areas (Stuart & Podolny, 1996). Such studies show that technological boundaries may have two dimensions: general boundaries between broad technological fields when knowledge creation in one field builds on knowledge from another field, such as optical or non-optical disk technology (Rosenkopf & Nerkar, 2001), or the boundaries of the range of expertise, such as Mitsubishi's technological space (Stuart & Podolny, 1996). In this context, to generate new competencies, firms may combine knowledge taken from different technological fields, some that lie beyond the firm's specialized technological fields (Kogut & Zander, 1992). In other words, non-localized searches may involve spanning technological boundaries in both senses.

Many MNCs have invested substantial resources to upgrade their subsidiaries in China. In 1993, Motorola established China's first foreign-owned R&D centre. By the end of 2005, MNCs had opened about 750 foreign-owned R&D centres in China (The Ministry of Commerce of China, 2006). An MNC is unlikely to invest heavily in a subsidiary's R&D capacity just to transfer technological knowledge from the parent company to the subsidiary (Driffield, Love, & Menghinello, 2009). Rather, subsidiaries are expected to further build their technological capabilities by moving toward more exploratory activities that may require crossing organizational and technological boundaries in ways novel enough to potentially benefit the MNC. Consequently, as MNC subsidiaries in China initiate capability development, we expect them to rely on inter-organizational rather than in-house

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searches when exploring new combinations of technological knowledge taken from different fields, namely when reaching across general technological boundaries and when searching for knowledge in areas beyond the parent's specialized technological fields. Thus we propose our first hypotheses:

Hypothesis 1: Subsidiaries will more likely draw knowledge across general technological boundaries from inter-organizational sources than from intra-firm sources.

Hypothesis 2: Subsidiaries will more likely draw knowledge beyond the parent's technological expertise from inter-organizational sources than from intra-firm sources.

The age of knowledge may also play a role in the firm's non-localized search. Older inter-industry inter-organizational knowledge promotes innovation, but older intra-firm knowledge hurts innovation (Katila, 2002), at least partly because trying to absorb technologically distant knowledge may attenuate a firm's learning capability (Cohen & Levinthal, 1990; Nelson & Winter, 1982). So when distant knowledge has had time to become more widely diffused and better understood firms are more likely to discover opportunities to combine it with currently leading-edge activities in their own established areas of expertise. Because technological knowledge accumulation is path-dependent, firms tend to improve and diversify their technological portfolio by searching in areas that enable them to build on their technological bases (Cantwell & Barrera, 1998; Nelson & Winter, 1982; Pavitt, 1988). They search for external technological knowledge that complements their internal knowledge base (Cassiman & Veugelers, 2006), and which may be used mainly to improve local applications of established products or methods rather than to further develop in more novel directions. In this context, externally sourced knowledge is largely historically received knowledge that tends to be relatively older than internally sourced knowledge. Consequently, although sourcing knowledge beyond organizational boundaries is essential in non-localized searches, inter-organizationally sourced knowledge is likely to be older than intra-firm knowledge sources in combinations associated with better innovative performance.

Inter-organizationally sourced knowledge may vary in average age across subsidiaries, suggesting different levels of capability development. MNC subsidiaries in mature industrialized countries may find that they have accumulated sufficient absorptive capacity to support access and assimilation of newer inter-organizational knowledge. MNC subsidiaries in emerging markets, like their host locations, are still catching up. China still lags behind the home countries of many MNCs and other industrialized countries in terms of generating advanced technological and scientific knowledge, even though China has been actively facilitating the accumulation of such capabilities (OECD, 2007). A country's technological advantages usually depend mainly on the aggregate technological expertise of firms

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in that country (Frost, 2001). Foreign-owned subsidiaries in China may find that the technological knowledge from the host environment tends to be older than the knowledge their sister subsidiaries can find in their respective host countries. Indeed, foreign-owned subsidiaries in China could turn to other international knowledge sources, such as the clusters in mature industrialized countries, for more recent technological knowledge. However, the ability of foreign-owned subsidiaries in China to understand and absorb cutting-edge technological knowledge from external sources may still be limited given the short time-span of their development. In other words, the older the external knowledge, the more easily the subsidiary may absorb it.

Hypothesis 3: Technological knowledge derived from inter-organizational sources will tend to be significantly older than the knowledge derived from intra-firm sources.

Many MNCs have adopted a more decentralized network approach by recognizing subsidiaries' roles in accessing the idiosyncratic knowledge of various host locations that can be critical in identifying new technological opportunities (Dunning, 1998; Kuemmerle, 1999; Phene & Almeida, 2003). As a subsidiary gradually accumulates capabilities, new technological knowledge is likely to be generated by combining local inter-organizational knowledge with international intra-firm knowledge (Cantwell & Zhang, 2011).

Yet, not all host country environments can offer MNCs equally idiosyncratic knowledge. Host countries must first possess advanced science and technology capabilities, built over time, before they can generate such knowledge (Frost, 2001), which makes emerging markets so challenging. Given their early stage of industrialization, they are less technologically advanced and specialized than more mature industrialized countries – the home countries of many MNCs. A survey study of MNC subsidiaries in China found that most were inactive in local inter-firm knowledge exchange (Wang, Liu, & Li, 2009). Although local inter-organizational knowledge links benefit subsidiary capability development (Andersson, Bjorkman, & Forsgren, 2005; Andersson & Forsgren, 2000; Birkinshaw & Hood, 1998; Frost et al., 2002), few subsidiaries in China have been able to establish those meaningful links.

Searching for knowledge in international locations offers an alternative path for subsidiary capability development. Although non-localized search usually refers to knowledge search across organizational and technological boundaries, it can be broadly defined as search efforts beyond a firm's immediate contexts, including its geographical context (Rosenkopf & Almeida, 2003). Moreover, given the importance of international business connections for modernizing economies (Athreye & Cantwell, 2007), China has actively encouraged domestic firms and foreign entrants to develop and utilize international connections. In this context, MNC subsidiaries' external learning does not necessarily have to be geographically local.

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A study of MNC subsidiaries in Spain found that as subsidiaries accumulate capabilities, their primary learning channel shifts from the host country to wider international markets – from local inter-organizational to international inter-organizational knowledge sources (Alvarez & Cantwell, 2011; Wu & Wei, 2013). Since internal learning facilitates external learning (Cantwell & Mudambi, 2011; Cohen & Levinthal, 1990), subsidiaries in China, by relying on intra-firm knowledge links to a variety of international sources, might be able to connect to new inter-organizational knowledge sources of their own in international locations over time, and hence become more able to conduct non-localized searches beyond their immediate geographical context.

Hypothesis 4: Subsidiaries will more likely draw international knowledge from inter-organizational sources than from intra-firm sources.

METHOD

Data and Sample

To operationalize the variables required for this study, we used patents granted to the world's largest firms by the US Patent and Trademark Office (USPTO) for inventions attributable to their subsidiaries in China between 1996 and 2005. We used US patent data for several reasons. First, the USPTO grants patents only to inventions considered nontrivial, useful, and novel (Jaffe et al., 1993). Although we study the technological knowledge sourcing of foreign-owned subsidiaries in China belonging to different MNCs over a ten-year period, the USPTO has long enforced patent screening and legal procedures that guarantee quality and provide a standard for comparison across firms and over time (Cantwell, 2006), Second, US patent documents provide data on originating firms, geographic locations of inventions, technology classifications of inventions, and dates of patent applications and grantings. More important, patent documents list patent citations identifying a patent's 'prior art', which reveals its knowledge structure (Jaffe et al., 1993; Phene & Almeida, 2008). US patent data disaggregate by geographical, organizational, technological, and historical dimensions on a scale unachievable through other sources such as R&D data (Cantwell, 2006). Given the scarcity of emerging market data and the difficulties of collecting empirical data in emerging markets (Burgessa & Steenkamp, 2006), the richness of patent data makes emerging market studies more viable, despite potential random noise associated with patent citations (Griliches, 1990). Third, the US is the world's largest and technologically most-developed market, so many large firms apply for US patents for inventions they believe may have the greatest impact (Archibugi, 1992; Cantwell, 2006). Thus, if parent companies see that foreign-owned subsidiaries in China have invented strategically important

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technologies, they are likely to authorize applications for US patents. The USPTO-patented technologies therefore codify the most important elements of the technological capability accumulation of foreign-owned subsidiaries in China.

Historically, researchers have debated the advantages and disadvantages of using patent and patent citation data (see Cantwell, 2006, for a detailed review). One concern relevant to our study is whether patent citations represent real technological knowledge flows (Alcacer & Gittelman, 2006; Griliches, 1990). Several studies have shown that patent citations are valid and reliable proxy measures of knowledge flows (Duguet & Macgarvie, 2005; Jaffe, Trajtenberg, & Fogarty, 2000). More importantly, we are interested in the structure of knowledge accumulation as an indicator of the nature of technological capability development by foreign-owned subsidiaries in China, rather than as a means of tracing subjective relationships that may have supported the underlying antecedent knowledge flows – such as whether the inventor of a citing patent knew personally or was even aware of the work of the inventor of a cited patent, as opposed to becoming aware of the relevant knowledge through a wide variety of indirect channels. A citation added by patent examiners represents a legitimate component of the knowledge drawn on and used by the inventors. The rigorous USPTO examination procedures make patent citations a relatively objective method of measuring the knowledge structure and characteristics underlying a citing patent.

We linked a subsidiary to its corporate family using '*Who Owns Whom*', which provides the relationship between companies worldwide showing the ultimate ownership structures of MNC groups. While an MNC's overseas affiliate could be legally independent, it is still recognized as a subsidiary of the MNC based on ownership relationships. We also checked mergers and acquisitions (M&As) between the world's largest firms in 2005 to adjust their affiliations over time. Some MNCs may assign patents of subsidiary inventions to their headquarters, so we determined whether a patent could be attributed to the technological efforts of subsidiaries in China based on the location of the first inventor, and not the assignee, as recorded on the patent document. During the ten-year period, 554 patents were granted for inventions in China-located foreign-owned subsidiaries that were affiliates of 51 of the world's largest MNCs. With these citing patents as the reference category, we examined the pattern of the cited patents to indicate the technological knowledge sources. We thereby obtained 3,845 pairs of citing and cited patents.

Measures

Dependent variable. Our dependent variable (EXT) indicates whether a patent citation (a pairwise combination of citing and cited patents) falls into the category of

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inter-organizational knowledge sourcing. In other words, EXT equals 1 if the citing patent cites a cited patent assigned to another firm/organization, and 0 otherwise.

Independent variables. We classified patents into 56 technological fields by combining the classes and subclasses of the US patent class system (see Cantwell & Noonan, 2007) to measure the extent of knowledge accumulation across technological boundaries (Inter-Tech) through a pairwise matching of the technology fields of citing and cited patents. Inter-Tech equals 1 if a pair of citing and cited patents is not in the same technological field, and 0 otherwise.

We measured the technological expertise of each MNC by calculating an index of 'revealed technological advantage' (RTA) of the MNC in each technological field, which allowed us to control for inter-field and inter-organizational differences in patent propensity (Cantwell, 1995; Cantwell & Piscitello, 2007). The RTA index is defined as follows:

$$\mathrm{RTA}_{ij} = \left(P_{ij} \Big/ \sum\nolimits_i P_{ij}\right) \Big/ \left(\sum\nolimits_j P_{ij} \Big/ \sum\nolimits_{ij} P_{ij}\right), \tag{1}$$

where P_{ij} is the number of patents granted to MNC i in technological field j. Values greater than 1 suggest that the MNC i is comparatively advantaged in the technological field j relative to the world's other largest MNCs, while values less than 1 indicate comparative disadvantage.

Knowledge accumulation across geographical boundaries (L) was measured by comparing the geographical locations of the inventors of each pair of citing and cited patents. L equaled 1 if the inventor of a cited patent was located in China, and 0 otherwise. For each pair of citing and cited patents, technological knowledge age (AGE) was measured by the difference between the grant years of the citing and cited patents.

Control variables. We controlled for the grant year of citing patents (Y) and subsidiary age (S_{age}). Industry dummies (IND) and home country/region dummies (HM) were included to control for the possible industrial and home country/region effects. The food industry and Taiwan were the baseline categories for the IND and HM dummies, respectively. We chose Taiwan as the reference group for HM because of the geographical proximity and psychological connection between Taiwan and Mainland China.

Analyses

Since EXT is a dichotomous variable that takes values of 1 and 0, we employed a probit regression technique. The model may be expressed formally as:

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$$\Upsilon = f(X, C), \tag{2}$$

where Υ is the probability of technological knowledge coming from inter-organizational sources, viz. the probability of inter-organizational knowledge sourcing (EXT) equaling 1; X is a vector of independent variables, and C is a vector of control variables.

RESULTS

Table 1 reports the two-tailed Pearson correlation matrix of most variables in this study. Given the number of industrial and locational dummies, we did not report their correlation coefficients in Table 1. (The full correlation matrix is available on request.) No problematic correlations were observed among the explanatory variables.

The results of the probit regressions are reported in Table 2. All models in the table are statistically significant. Model 1 includes only control variables, and serves as the baseline model. Models 2 to 5 add independent variables to the baseline model. The coefficients on the independent variable 'Inter-Tech' are significantly positive across all models. In other words, foreign-owned subsidiaries in China are more likely to access inter-organizational knowledge sources in technological fields that differ from those in which the firm itself is creating new knowledge. Therefore, Hypothesis 1 is supported. The coefficients on a firm's RTA are significantly negative across all four models. This is consistent with our expectation in Hypothesis 2 that foreign-owned subsidiaries in China tend to rely on inter-organizational sources for fields of technological knowledge in which the MNC is not specialized. Put differently, intra-firm knowledge sources tend to be more important in areas where the MNC has its own focus of specialization in knowledge development. In this sense, to create new competences, subsidiaries tend to combine inter-organizationally sourced technological knowledge in areas relatively peripheral for the firm with intra-firm-sourced technological knowledge from within the MNC's core areas of strength. It is common for a new patented invention to cite both these strands of underlying knowledge sources, which implies that the process of developing new knowledge generally relies on the capacity to build on this form of combination. The significantly positive coefficient on the variable AGE suggests that foreign-owned subsidiaries in China access inter-organizational knowledge that is significantly older than that taken from intra-firm sources. This result therefore supports Hypothesis 3 and suggests that the host country is limited in its ability to generate a wider range of advanced technological and scientific knowledge, and that the subsidiary is limited in its ability to absorb newer technological knowledge from inter-organizational knowledge sources. The independent variable measuring geographically local knowledge sourcing (L) is significantly negative. Thus, Hypothesis 4 is supported. While one might expect that the

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Table 1. Descriptive statistics and correlation matrix

Variables		*N*	*Mean*	*Std Dev*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1	Inter-organizational Knowledge (EXT)	3845	0.77	0.42	1						
2	Inter-technological Field Knowledge (Inter-tech)	3845	0.20	0.40	0.15*	1					
					0.00						
3	Firm's Revealed Technological Advantage (RTA)	3845	9.45	13.25	−0.06*	−0.18*	1				
					0.00	0.00					
4	Geographically Local Knowledge (L)	3845	0.04	0.20	−0.36*	−0.07*	0.03*	1			
					0.00	0.00	0.03				
5	Knowledge Age (AGE)	3845	7.58	10.08	0.23*	0.09*	0.17*	−0.12*	1		
					0.00	0.00	0.00	0.00			
6	Year (Y)	3845	2003	1.53	−0.02	−0.02	−0.22*	0.05*	−0.04*	1	
					0.35	0.22	0.00	0.00	0.01		
7	Subsidiary Age (S_{age})	3845	13.45	3.92	−0.16*	−0.17*	−0.07*	0.09*	−0.06*	0.36*	1
					0.00	0.00	0.00	0.00	0.00	0.00	

Notes: * $p < 0.05$.

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Table 2. Probit regression coefficients for variables predicting inter-organizational knowledge accumulation

Variables	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
Intercept	66.34	74.66	75.67	120.59	72.19
Inter-technological Field Knowledge (Inter-tech)		0.41***	0.33***	0.33***	0.33***
Firm's Revealed Technological Advantage (RTA)			−0.01***	−0.02**	−0.01***
Knowledge Age (AGE)				0.09***	−0.08***
Geographically Local Knowledge (L)					−2.10***
Year (Y)	−0.03	−0.04	−0.04	−0.04	−0.04
Subsidiary Age (S_{age})	0.02	0.02	0.02	0.01	0.01
Industry (IND)					
Chemicals	−0.68	−0.75*	−1.53***	−1.07*	−0.99*
Pharmaceuticals	−0.99**	−0.90**	−1.66***	−1.32**	−1.20**
Metals	0.48	0.52	−0.31	−0.26	0.35
Electrical Equipment	−0.31	−0.21	−1.04**	−0.30	−0.20
Office Equipment	−0.20	−0.08	−0.91*	−0.14	−0.02
Motor Vehicles	0.79	0.80	0.72	1.07*	1.00
Aircraft	0.22	0.25	−0.55	−0.73	−0.63
Paper Products	−0.04	0.07	−0.74	−0.78	−0.66
Non-metallic Mineral Products	−1.53***	−1.48***	−2.15***	−2.61***	−2.31***
Other Manufacturing	−1.47**	−1.37**	−2.26***	−1.48***	−1.45*
Home Country (HM)					
USA	−0.08	−0.03	0.02	0.00	−0.02
Japan	0.02	−0.04	−0.04	−0.04	0.01
Other Countries	−0.76***	−0.69***	−0.59***	−0.47***	−0.43***
Likelihood Ratio – Chi Square (df)	276.22(15)***	309.29(16)***	321.72(17)***	656.59(18)***	912.84(19)***
Pseudo R-Square	0.07	0.08	0.08	0.16	0.23

Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

international knowledge links between younger subsidiaries would largely be constituted by intra-firm sources, including the subsidiary's parent in the home country and sister subsidiaries in other countries, our regression results show that foreign-owned subsidiaries in China tend still more to access inter-organizational sources of international knowledge. This finding has important implications for MNCs and for government policy, as we discuss in the next section.

Variables controlling for time effect Y and subsidiary age (S_{age}) are not statistically significant across all models. Industrial controls show that subsidiaries of MNCs in the chemical, pharmaceutical, nonmetallic mineral products, and other manufacturing industries are more likely than those in the food industry (the baseline industry) to rely on intra-firm knowledge sources. Finally, the firms of other countries/regions are less likely than Taiwanese firms to access inter-organizational knowledge. Given the geographical and psychological proximity between Mainland China and Taiwan, the subsidiaries of Taiwanese firms are expected to be better embedded in the local environment.

DISCUSSION

Subsidiary capability development has been studied extensively among subsidiaries located in mature industrialized countries. Researchers have said comparatively little, however, about learning patterns in overseas subsidiaries in some rapidly developing emerging markets. In this study, we focus on foreign-owned subsidiaries in China for their technological knowledge accumulation, knowing that foreign entrants often need technological knowledge as bargaining chips for success in emerging markets (Hitt et al., 2005; Li et al., 2010a). The study period, 1996–2005 saw the initiation of more advanced technological capability development in foreign-owned subsidiaries in China following a wave of substantial parent R&D investments there. We argue that more open network structures recently emerging in many MNCs has been an important mechanism for subsidiary technological capability development in emerging markets by facilitating access to technologically diversified knowledge from inter-organizational knowledge sources in geographically distant locations.

Our statistical results show that foreign-owned subsidiaries in China have been able to combine knowledge in different technological fields by sourcing inter-organizationally and internationally, spanning general technological boundaries, and searching beyond the MNC's core technological expertise. We find that Chinese-located subsidiaries have increased their absorptive capacity by assimilating knowledge from their external environment. As we expect, in their accumulation of technological knowledge, they have taken inter-organizational knowledge from other firms/organizations outside China, and that knowledge has played a much more important role than local inter-organizational knowledge. This finding is consistent with our argument that non-localized searches beyond a geographically

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bounded local context is critical for subsidiary technological capability development in a host environment that has less-advanced technological knowledge. For foreign-owned subsidiaries in China, international inter-organizational and intra-firm knowledge linkages have been combined for new technological knowledge generation, whereas subsidiaries in mature industrialized countries usually combine international intra-firm and local inter-organizational knowledge for their technological innovations (Andersson & Forsgren, 2000; Cantwell & Zhang, 2011; Frost et al., 2002).

Theoretical Implications

By moving from relatively closed and top-down network structures toward more open and distributed network structures, MNCs may gain advantages through spatially dispersed organization and multinationality for discovering geographically distant inter-organizational knowledge sources (Zander, 1998). Researchers know that achieving success through activities associated with competence-augmenting FDI is relevant (Dunning, 2009; Kuemmerle, 1999). Yet discussion of more internationally distributed knowledge sourcing has largely remained at an MNC corporate level. We move the analysis to a subsidiary level, and show that individual subsidiaries may also take advantage of more open networks to draw on diversified inter-organizational knowledge sources. Such diversified knowledge refers not only to crossing technological fields and expertise boundaries, but also to drawing on knowledge derived from different geographical locations. In this context, we formulate subsidiary technological capability development as a process that increasingly relies on non-localized searches, and we broadly define non-localized search as knowledge search beyond a firm's limited contexts. Although previous literature on non-localized search has focused on firm-level knowledge search beyond organizational and technological boundaries (Rosenkopf & Nerkar, 2001; Stuart & Podolny, 1996), or knowledge search beyond technological and geographical boundaries (Rosenkopf & Almeida, 2003), we attempt to jointly consider all three boundaries and empirically examine the pattern of subsidiary-level non-localized searches across organizational, technological, and geographical boundaries in a fast-growing emerging market context. Moreover, by looking at the structure of MNC subsidiaries' knowledge accumulation in emerging markets, rather than the eventual outcomes previous research has often used to measure subsidiaries' capability development in mature industrialized countries, this new approach better captures the subtle characteristics of early-stage capability accumulation in China's foreign-owned subsidiaries. Although we do not compare MNC subsidiary capabilities internationally, an equivalent approach would also facilitate a cross-country comparison of subsidiary capability development, which would avoid the potential bias of performance measures from environmental variations and stages of subsidiary development in different locations.

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Parent–subsidiary knowledge transfer usually sets the initial technological foundation for overseas subsidiaries. Such international intra-firm knowledge transfer is particularly important for MNC subsidiaries in emerging markets because it reduces external dependence and mitigates emerging market threats (Luo, 2003), or protects the MNC's intellectual property rights (Zhao, 2006). On the one hand, this is consistent with our findings that foreign-owned subsidiaries in China are less likely to source local technological knowledge as they generate new knowledge. On the other hand, MNC subsidiaries possess technological knowledge that usually offers a bargaining chip in emerging markets to initiate mutual learning with local firms (Hitt et al., 2005; Li et al., 2010a,b). In this sense, MNC subsidiaries become potential spillover channels for their parents' technological knowledge. MNC restructuring toward a relatively more open network structure suggests that the organizational boundary between the MNC and its external environment is increasingly blurred (Cantwell, 2013; Laursen & Salter, 2006). In a more open innovation system, firms are expected to source more knowledge from their external environment and also to contribute more knowledge externalities to it (Chesbrough, 2003; Singh, 2007). Thus, the important role we have found for international inter-organizational knowledge sourcing suggests that China's foreign-owned subsidiaries may become a conduit for knowledge spillovers for the host country by providing connections to a wider range of technological knowledge sources in other international locations often beyond the MNC's organizational boundaries (Li, Chen, & Shapiro, 2013).

Limitations and Future Research

As one of the first attempts to understand the early capability development of foreign-owned subsidiaries in China, this study inevitably suffers from some limitations. We used US patent data to analyze the subsidiaries' technological knowledge structure. The richness of patent data helps to capture some of the advanced technological capability accumulation, which meets our purpose. Yet, the data cannot capture organizational learning mechanisms or processes. For instance, our definition of intra-firm and inter-organizational knowledge sourcing omits firms that closely but independently collaborate with the MNC, with no ownership relationship. Inter-organizational knowledge linkages between such firms and the MNC may have a special status compared with other inter-organizational knowledge linkages, or more distant and indirect connections. Future research may explore organizational learning by employing both patent data and primary survey data when looking at subsidiaries in emerging markets. Moreover, we focus on China in our analysis, so generalization of the results to other emerging market economies must be undertaken with caution, although our method of investigating subsidiary capabilities from the perspective of knowledge accumulation has the potential to facilitate cross-country comparison. Finally, our data show that foreign-owned subsidiaries in China dramatically changed their knowledge accumulation patterns

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from 1996 to 2005, and that they rapidly began catching up in terms of patent generation after 2000. Although we expect certain knowledge accumulation patterns will continue for some time among China's foreign-owned subsidiaries, we cannot assume that our results will continue on the same path after 2005 without further justification and analysis. Future studies incorporating data after 2005 and MNC subsidiaries in other emerging economies would build a more comprehensive picture of the structure of technological knowledge development of foreign-owned MNCs in emerging market economies.

Practical Implications

For MNCs, our findings have two managerial implications. First, MNC managers must realize that intra-firm and inter-organizational knowledge sources might sometimes be differently connected to generate new knowledge in locally distinctive ways. That is especially true in emerging markets where subsidiaries have only recently initiated technological capability accumulation, and where the economy is fast growing but structurally volatile with relatively underdeveloped country-level technological and scientific capabilities. Managers should allow and encourage subsidiaries to interact creatively with internal and external environments on the premise of protecting the MNC's critical intellectual property rights. Although centres of excellence may still emerge in non-dynamic locations where local external linkages are weak (Frost et al., 2002), such autonomy at subsidiary levels is essential for MNC subsidiaries in emerging markets to experiment with new ways of creating competence that fit local conditions and even accelerate forming new and possibly idiosyncratic centres of excellence within the MNC's international knowledge generation network. Second, because new knowledge is generated by combining existing and acquired knowledge, or by recombining existing knowledge (Kogut & Zander, 1992), MNC managers may want to pay more attention to the knowledge their subsidiaries accumulate in emerging markets. For instance, while China's foreign-owned subsidiaries have actively drawn on inter-organizational knowledge in countries outside their home and host countries, they must have accumulated knowledge that is associated with those international locations that is not available within the MNC. Otherwise, the subsidiary would have drawn the knowledge from intra-firm sources given the more efficient intra-firm knowledge transfer (Kogut & Zander, 1992; Miller, Fern, & Cardinal, 2007). This knowledge may diversify the MNC's knowledge pool and thereby create new technological opportunities.

Emerging markets often have government policies encouraging foreign R&D investments. For instance, China's corporate income tax law offers reduced corporate income tax rates for new and high-tech enterprises, super deduction of R&D expenses, and corporate income tax holidays for certain high-tech firms. Moreover, foreign firms eligible to enter some high-tech industrial parks in China may enjoy other privileges such as preferred location, lower utility rates, and

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priority access to local human resources (Yong & Zhou, 2009). Most policies that have proved effective in attracting R&D investments in China could also help generate positive technological knowledge spillovers from foreign entrants to local firms. The content of the spillovers at least partly reflects the technological expertise of the subsidiary's parent, which in turn also partly reflects the technological advantages of the MNC's home country. However, whether such policies can sustain the desired technological spillovers over time is questionable. Our study shows that as foreign-owned subsidiaries in China evolve, they tend to draw technological knowledge from international locations outside China and outside the subsidiary's home country. Given that international business connections are important for economies striving to catch up, our findings suggest that the Chinese government should consider policies that encourage foreign-owned firms based in China to explore international knowledge. Such subsidiary efforts offer a means of providing potential international knowledge linkages that may create further knowledge spillovers to local firms and organizations in addition to the initial knowledge spillovers in the fields of the subsidiary's parent's expertise and home country technological advantages. Moreover, this study focuses on the early stage of subsidiary technological capability development in China when the host environment still lacked advanced scientific and technological knowledge. Yet our findings suggest that a country's possession of advanced technological knowledge need not be a prerequisite to attract MNCs' competence creation facilities; rather a country's openness to international connections may matter more. Consequently, for countries striving to modernize their economies, an open attitude toward using international knowledge sources is essential.

CONCLUSION

In this study, we investigate foreign-owned MNCs in China during the early stage of technological capability development, between 1996 and 2005. We show that MNCs' recent propensity for open network structures has enabled subsidiaries in China to develop technological capabilities by searching diversified interorganizational knowledge sources beyond the geographically local context to compensate for internal limitations and the deficiencies of their host environment. Our findings contribute to the literature on MNC organizational restructuring, subsidiary evolution, and subsidiary-level non-localized search, and suggest important implications for knowledge spillovers, MNC knowledge management, and government policies.

https://doi.org/10.1111/more.12026 Published online by Cambridge University Press

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Manuscript received: April 17, 2011
Final version accepted: June 15, 2013
Accepted by: Marjorie A. Lyles

https://doi.org/10.1111/more.12026 Published online by Cambridge University Press