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Version: Accepted Version

Article:
Liu, X, Vehtera, P, Wang, C et al. (2017) The delicate balance: Managing technology adoption and creation in multinational affiliates in an emerging economy. International Business Review, 26. pp. 515-526. ISSN: 0969-5931

https://doi.org/10.1016/j.ibusrev.2016.11.002

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THE DELICATE BALANCE: MANAGING TECHNOLOGY ADOPTION AND CREATION IN MNE AFFILIATES IN EMERGING ECONOMIES

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ABSTRACT

From a perspective of the resource-based view, this paper analyzes the inter-connection between technology adoption and creation in affiliates of multinational enterprises (MNEs) in an emerging economy. Operating below the international technological frontier, multinational affiliates are more motivated to adopt technologies already existent from their MNEs than create new technologies, as the former already gives them competitive advantages over local firms. When technology creation is required, multinational affiliates will adopt further technology-based resources from their MNEs as they are unavailable in an emerging economy. As a result, technology adoption is a necessary but not sufficient condition for multinational affiliates to conduct technology creation. Given that networks are particularly important for working around institutional voids in the context of an emerging economy, this paper also investigates the different roles of R&D support from internal and external networks of multinational affiliates in technology adoption and creation. Hypotheses are tested and partially supported based on unique data from 465 multinational affiliates in China.

Key Words: Resource-based View, Technology Adoption, Technology Creation, Multinational Enterprises, Emerging Economy, China.

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1. INTRODUCTION

Does technology adoption facilitate technology creation and/or vice versa? Though technology adoption (or technology transfer) and technology creation (or innovation)[1] are arguably two of the most widely researched topics in the literature on R&D and strategy, they tend to be examined separately (e.g. Almeida & Phene, 2004; Chung, 2001; Cui, et al., 2006; Cummings & Teng, 2003; Damanpour & Schneider, 2006; Frost, 2001; Mowery, et al., 1996; Mudambi, et al., 2014; Simonin, 2004; Tortoriello, 2014; Tsai, 2001; Zhao & Anand, 2013). To the best of our knowledge, there is limited research focusing on how they are connected; especially in context of affiliates of foreign multinational enterprises (MNEs) in emerging economies. This is partially related to how the role of multinational affiliates in emerging economies is viewed. The conventional view tends to consider multinational affiliates as technology adopters, adopting technologies possessed by the parents or sister affiliates given the relative more advanced technology level of home countries to that of emerging economies (Athreye, et al., 2014; Dunning & Lundan, 2008; Kuemmerle, 1999). Increasingly, there is a recognition of multinational affiliates taking on the role of technology creator, creating technologies of their own for local production which could also be shared across the MNE (Mudambi, et al., 2014; Zhao & Anand, 2013). Kuemmerle (1999) and Cantwell and Mudambi (2005) distinguish the

[1] We use the terms of technology adoption and technology creation because this paper takes the perspective of multinational affiliates. For these affiliates, their technology mandates are related to adopting and/or creating technologies.

mandate of multinational affiliates as either technology adoption or technology creation. However some multinational affiliates may take the synchronous roles of both technology adopter and technology creator (Forsgren, 2008; Narula, 2014). Thus technology adoption and technology creation might be interconnected. Understanding a firm's R&D strategy, i.e. the plan that guides its decision on the development and use of technological resources and capabilities, is of great value for achieving market and financial success.

Although the extant literature treats technology adoption and creation separately, scholars have suggested a bi-directional and positive relationship between technology adoption and creation. On the one hand, successful technology adoption stimulates an affiliate's creation of new technologies (Almeida & Phene, 2004; Ghoshal & Bartlett, 1988). On the other, technology creation leads to a greater demand for advanced technologies owned by other organizational units in the differentiated network of the MNEs (Athreye, et al., 2014). Thus there is a potential endogeneity issue that needs to be taken into account: do technology adoption and technology creation mutually influence each other? Put it differently, a full understanding of a multinational affiliate's technological activities requires the consideration of technology adoption and creation in an integrated framework. This is particularly important in the context of emerging economies because multinational affiliates are often constrained by resources and institutional environment and face difficulties in creating new competencies (Chung, 2001).

Indeed, "institutional voids" have been much emphasized in understanding international business in emerging economies (e.g. Hoskisson, et al., 2000; Khanna & Palepu, 2010; Khanna & Rivkin, 2001, 2006; Meyer & Nguyen, 2005; Peng, et al., 2008). Institutional voids result from a lack of

market-supporting formal institutions and can have profound impact on a firm's R&D strategy. Institutional voids lead to the escalation of transaction costs arising from regulatory and bureaucratic burden, the enforcement of contracts, security and safety, and the state of corruption. Facing challenging formal institutional environments, firms establish strategies and structures which increase organizational flexibility so as to deal with missing or poorly developed markets (Dieleman & Boddewyn, 2012; Dixon, et al., 2010). Institutional voids undermine firm's ability to access and utilize resources required to support or stimulate technology adoption and creation. By its very nature, resources are scarce. Managing and allocating resources for efficient and effective use is a key to business success. Technology adoption and creation impose different levels of requirement on firm resources. Technologies adopted by affiliates sometimes need to be adapted to the local context and this process can put a strain on the affiliate's available resources (Chung, 2001). However, creating new technologies for local markets imposes even greater resource requirement due to the need to search, develop, transfer, understand, and integrate new knowledge (Cohen & Levinthal, 1990; Makadok & Barney, 2001). Therefore, considering the limited resources available, it is a perennial challenge how multinational affiliates in an emerging economy resolve the balancing act between technology adoption and creation.

In view of institutional voids, it has been widely recognized in the literature that informal institutions come in as a substitute for the missing or imperfect product and factor markets and for dealing with market uncertainty and volatility (e.g. Khanna & Rivkin, 2006; Li, 2005; Park & Luo, 2001; Peng & Luo, 2000). Indeed, it is important to note that in emerging economies such as China, it is not only domestic firms, but also foreign companies that cultivate their networks to

support their strategies and to alleviate market failures (Hitt, et al., 2004; Hitt, et al., 2000; Li, 2005). Thus, different from operating in developed countries which are characterized by market-supporting institutions, managers in emerging economies particularly rely on networks, both internal and external, for smooth business transactions and exchange coordination as substitutes for formal institutional support because networks provide them with much-needed resources for R&D strategy (Peng and Luo, 2000). Thus different from the previous literature that focuses on firm-level variables as technological capabilities variables (human capital, tangible support assets and technology gap) (e.g. Driffield, et al., 2010; Kedia & Bhagat, 1988; Simonin, 2004; Stock, et al., 1996) and organizational variables (ownership form, foreign equity share and autonomy) (e.g. Belderbos, 2003; Desai, et al., 2004; Ghoshal & Bartlett, 1988), we pay attention to the different roles of R&D support from internal and external networks in technology adoption and creation. To the best of our knowledge, the *simultaneous* impact of internal and external networks has not been examined in the extent literature.

This paper contributes to two strands of literature. The first is the resource-based view (RBV) which draws on information economics aiming to uncover key strategic factors underpinning the adoption and creation of valuable resources (Makadok & Barney, 2001). From a perspective of RBV, we develop and test a conceptual framework that is firmly placed in the context of an emerging economy taking into account its formal institutional voids, and we advance the understating of multinational affiliates' R&D strategy by investigating the interconnection between technology adoption and technology creation. We first argue that such an economy has important resource implications for multinational affiliates, especially for balancing adopting existing technologies and creating new ones. Contrary to the existing literature, we argue that the

relationship between technology adoption and creation can be uni-directional rather than bi-directional in emerging economies. We propose, and empirically demonstrate, that technology creation in multinational affiliates in emerging economies heavily relies on technology adoption. In contrast, technology adoption does not necessarily lead to technology creation.

We provide a more fine-grained picture of a multinational affiliate's R&D strategy in an emerging economy by analyzing the influence that both internal and external network resources could have on technology adoption and creation (cf. Moreno-Luzón & Begoña Lloria, 2008). By analyzing networks, we clarify boundaries within which they influence technology adoption and creation in an emerging country context. The consideration of internal and external networks in an emerging economy context also contributes to the literature on formal and informal institutions. In particular, we extend the literature on networks as an informal institution in a weak formal institutional environment (e.g. Khanna & Rivkin, 2006; Li, 2005; Park & Luo, 2001; Peng & Luo, 2000; Peng, et al., 2008) by relating internal and external networks to technology adoption and development.

The second strand we contribute to seeks to understand firm strategy in emerging economies (Hoskisson, et al., 2000; Khanna & Palepu, 1997; Wright, et al., 2005). We take a contextualized perspective and analyze specific environmental contingencies affecting technology adoption and creation (cf. Damanpour & Schneider, 2006). We thus move away from a simplistic way of treating technology adoption and technology creation as separate cases, which is often the feature of the extant studies, by taking into account their inter-connection and the simultaneous role of

internal and external networks, and revealing the effect of an emerging-economy context in technology adoption and creation within multinational affiliates.

2. THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

Following the RBV, technology is an important type of a firm's valuable, rare, inimitable, and non-substitutable resources (including capabilities) that determine its competitive outcomes (Barney, 1991). In the current highly competitive globalized world, an MNE's performance rests on its capability to effectively create technologies and transfer them between affiliates (D'Agostino & Santangelo, 2012). Indeed, one recent and most striking feature of MNE innovation activities is the internationalization of R&D into developing countries, especially BRIC countries (Brazil, Russia, India and China) (UNCTAD, 2005). However, internationalization of R&D into these locations seems somewhat counter-intuitive.

A typical emerging economy is characterized by (1) relatively underdeveloped factor and product markets, (2) resource-constrained local firms, and (3) underdeveloped, but rapidly changing political, economic, and social institutions (Hoskisson, et al., 2000; Khanna & Palepu, 1997; Wright, et al., 2005). Such characteristics coupled with weak intellectual property protection (IPP) indicate that indigenous firms in emerging economies often fail to devote sufficient resources to R&D and they are followers of technology (UNCTAD, 2005). In contrast, established MNEs are normally resource-abundant (Li, et al., 2008b) and are owners of advanced technologies which offer them competitive advantages over emerging economy rivals. In addition to technology gap with emerging economy firms, R&D managers in multinational affiliates have grappled with issues like staff diversity, lack of loyalty and high turnover rates (Gassmann & Han, 2004). Considering all these challenging issues, why do MNEs internationalize R&D into emerging economies? In order to provide an explanation for this

seemingly puzzling development, it is important to assess (i) technology adoption and technology creation in multinational affiliates in combination, and (ii) how these are affected by networks, an important factor in the context of emerging economies given their use for substituting underdeveloped or imperfect product and factor markets and for dealing with market volatility and institution voids (Hoskisson, et al., 2000; Peng & Luo, 2000).

2.1 Technology adoption and technology creation

When an MNE expands internationally, its affiliate can take the role of either "technology exploiting", "technology-creating" or both (Forsgren, 2008). As a technology adopter, the affiliate obtains and utilizes technologies transferred from other parts of the MNE in order to exploit existing technology-based competitive advantages. From a RBV perspective, technology adoption and technology creation impose different resource requirements on an affiliate (Makadok & Barney, 2001). The former is built on the firm's existing trajectory and leverages the use of existing resources. Combining both internal resources and technologies transferred, a "technology-adopting" affiliate becomes the MNE's agent for exploiting its ownership advantage and can enjoy a superior competitive position in the local marketplace, particularly when the MNE is committed to developing a strong position in the host country (Delios & Beamish, 2001). The success of an affiliate is hence in part determined by its ability to adopt the technologies possessed by the MNE (Chung, 2001; Cui, et al., 2006).

On the other hand, a "technology-creating" affiliate tends to be associated with a shift to a different technological trajectory, as it requires the availability of more sophisticated resources.

Shortening product life cycles and increased global competition and demand have driven MNEs to step up their R&D efforts (e.g. D'Agostino & Santangelo, 2012; Frost, 2001; Kuemmerle, 1999). MNEs increasingly recognize the distinctiveness of different countries/locations as sources of R&D and tap into and activate these dispersed knowledge sources as part of the organization's wider innovation programs (D'Agostino & Santangelo, 2012; Frost, 2001). In China, for example, several MNEs have established cutting-edge research facilities that act as competence centers for the whole firm (Gassmann & Han, 2004).

The existing literature on technology mandates of MNEs in developed economies seems to suggest that technology adoption and creation reinforce each other as outlined in the Introduction. However, would this conclusion be equally applicable in an emerging economy context? Though, to the best of our knowledge, there is no research making the connections between technology adoption and creation in the context of multinational affiliates embedded within emerging economies, studies do show why MNEs expand their technology creation activities into some emerging economies and how these activities are linked to technology adoption. Despite the challenges (such as weak IPP) faced by MNEs in emerging economies, these countries have the advantage of the underutilized human capital at low costs, strong educational institutions and rapidly developed infrastructures, particularly information and communication technology infrastructures (D'Agostino & Santangelo, 2012). MNEs can use internal organizations to substitute inadequate external institutions. Zhao (2006) finds that technologies developed by MNEs with R&D in weak IPP countries show stronger internal linkages which allow MNEs to appropriate value from their R&D even in the absence of strong IPP without being exposed to excessive risk. This may explain why some emerging economies

are now emerging as nodes in the R&D networks of MNEs (UNCTAD, 2005). This line of analysis also indicates that technology creation by multinational affiliates in an emerging economy tend to make more use of internal R&D network to adopt technologies.

Nevertheless, to explore the relationship between a multinational affiliate's technology creation and technology adoption, we need to examine the nature of prevailing technology activities in an emerging economy. UNCTAD (2005) observes that most of R&D carried out by MNEs in developing countries has traditionally been of an adaptive nature, although recently more sophisticated activities are also expanding (pp. 127-128). In an emerging economy, local conditions can be significantly different from those at the origin of the technology. Therefore, there is a need for adaptation of technologies or products for local markets.

Although adaptive R&D is the dominant part of R&D in an emerging economy, multinational affiliates are sometimes required by their parent firms to create new technologies for either the local or global market. To do so requires technology-based resources. Resource requirements for technology creation often go beyond what a multinational affiliate possesses and the affiliate needs to obtain access to further knowledge or resources from other sources. Actually, most learning, mastery and adaptive activity requires close and continuous interaction with other enterprises like suppliers, subcontractors, competitors and consultants, and even public R&D institutes and universities (Edquist & McKelvey, 2001). Because of resource constraints and underdeveloped institutions, local support and supply structures are weak. Under such conditions, absorption and adaptation of technology are especially challenging (UNCTAD, 2005, pp. 102). The affiliate, therefore, would rely more on technology-based resources from the rest of

the MNE to support its adaptive innovations. Furthermore, low levels of technological turbulence (such as often present in emerging economies) imply relatively low need for creating new technologies. The adaptive nature of technology creation by a multinational affiliate based in an emerging economy can well lead to internal technology adoption.

The above phenomenon is actually confirmed by Wang, et al. (2009) who find that a relatively large proportion of multinational affiliates in China are the so-called "external loners", i.e., they are linked internally one way or another in the process of knowledge learning and diffusion, but isolated from possible external networks. Knowledge and skills in emerging economies are not seen to be important to some multinational affiliates, especially those from developed countries which are technology leaders.

On the other hand, the superior position of multinational affiliates over indigenous firms indicates that there is not much pressure for such an affiliate to conduct its own R&D and develop new technology-based resources. In other words, the multinational affiliate would tend to use technologies already existent in the internal MNE network rather than conduct its own R&D (Manea & Pearce, 2006) because internal technology adoption provides the affiliate with a sufficiently high level of technology-based resources to compete with local firms. Thus, internal technology transfer from the rest of the MNE to an affiliate complements the affiliate's own technological knowledge and becomes particularly important for successful operations in an emerging economy (Jindra, et al., 2009). Technology adoption enables the affiliate to be highly competitive and hence reduces the affiliate's incentive for technology creation.

The central message from the above discussion is as follows. Operating below the international technological frontier, multinational affiliates are more motivated to adopt technologies already existent from their MNEs than create new technologies, as the former already gives them competitive advantages over local firms. When technology creation is required, multinational affiliates will adopt further technology-based resources from their MNEs as such resources are likely to be unavailable in an emerging economy. As a result, technology adoption is a necessary but not sufficient condition for multinational affiliates to conduct technology creation. Thus, we have hypothesis 1 as follows:

> *Hypothesis 1: The relationship between technology adoption and technology creation in a foreign multinational affiliate in emerging economy can be uni-directional in that technology adoption increases with a high level of technology creation but technology adoption does not necessarily lead to technology adoption.*

2.2 Business network support

Turning attention to the role of networks in technology adoption and creation in multinational affiliates, as mentioned above, the institution of an emerging economy is often under-developed, characterized by resource scarcities, continuous economic liberalization, and the lack of an adequate legal and regulatory framework (Hoskisson, et al., 2000). Networks are often used for substituting missing or imperfect product and factor markets and for dealing with institution voids (Peng & Luo, 2000; Zhao, 2006). Networks are a core strategic resource for firms because they are valuable, rare, inimitable and non-substitutable (Adler & Kwon, 2002; Foss, 1999; Lavie, 2006; Li & Zhou, 2010; Peng & Luo, 2000). Networks are a private good, where they

primarily benefit those who possess them (Uzzi, 1999). A well-networked affiliate through interacting with internal and external agents can access extra resources and capabilities and identify opportunities for technology adoption and creation (Adler & Kwon, 2002; Li & Zhou, 2010). Therefore, resources and capabilities related to networks are valuable to economic agents that share them. Network is rare and inimitable because different networks are unlikely to possess the same level of resources and capabilities given the creation of networks is a path-dependent process, therefore, is unique and idiosyncratic to an affiliate. The complexity and ambiguity arising from the unique interactions between the focal affiliate and others in the network and the difficulty of replacing network resources by either similar or different resources for the same outcome make network non-substitutable (Foss, 1999).

A multinational affiliate is simultaneously embedded internally within the MNE and externally in the host-country environment (Almeida & Phene, 2004; Frost, 2001). The extant research has suggested that MNEs' internal and external networks are positively related to innovative and technological capabilities (i.e. financial support from parent and new local information from external sources) (e.g. Andersson, et al., 2002). However, recent studies such as Ciabuschi, et al. (2014) indicate the potential trade-off in simultaneous utilization of internal and external networks. First, a subsidiary needs to filter and absorb information and new and old technologies from both internal and external networks, hence leading to a balancing act between the two channels (Nell & Andersson, 2012). Second, the subsidiary must make decisions on the information and consequent resource requirements, for instance, whether to invest in technology adoption or creation of new technologies. Thus it is important to investigate the separate effects

of two separate network variables: internal business network support and external business network support.

2.2.1 Internal network support and technology adoption and creation

Following the discussion above, a multinational affiliate can, as part of the MNE, access knowledge within the MNE's internal network (Andersson, et al., 2014; Ghoshal & Bartlett, 1988). The provision of technology and managerial assistance by the MNE facilitates technology transfer and adoption (Lyles & Salk, 1996; Tsang, 2001). Organizations and their members also acquire knowledge from others through 'grafting' individuals with special expertise, such as using expatriates (Lyles & Salk, 1996). In addition, Ghoshal and Bartlett (1988) argue that high levels of normative integration between the headquarters and the affiliate will facilitate adoption and diffusion of innovations by the affiliate.

We argue that there are several mechanisms underpinning why internal network support might not be important for technology creation. First, an affiliate's mandate might not simply emphasize creation of new technologies, and therefore high degree of internal network support is not needed (Achcaoucaou, et al., 2014; Cantwell & Mudambi, 2005; Manea & Pearce, 2006). Second, it could be that creation of new technology is to some degree part of the affiliate's mandate, but internal support is limited due to other organizational constraints (e.g. resource limitations, lack of leadership, and external environment). Indeed, in contrast to technology adoption, technology creation imposes a higher order on an affiliate than technology exploitation/adoption in terms of needed resources (Ghoshal & Bartlett, 1988). It requires the

affiliate to scan its own internal resource and knowledge stock, and build on the core competencies of the MNE and the locational advantage of the host country. Internal network R&D support in terms of resources is a requirement for developing new technologies and upgrading existing ones, particularly in an emerging economy context. Finally, it could be that there is a mandate to create new technologies, as well as support from the organization, but the support provided through internal networks is not effective. For example, production of new technology is dependent on the level of existing knowledge. More technologically advanced and strategically important innovations require even further investments towards upgrading the available skills and knowledge embedded within the multinational affiliate. Hence, a more radical type of innovation is unlikely to take place without strong support from the MNE's internal networks. However, the extent to which the MNE will support innovative efforts of an affiliate in an emerging market with limited IPP and level of technical expertise is questionable. Instead, the utilization of existing technologies, knowledge, and resources may often be a safer choice as these are often enough for the affiliate to compete with local firms.

> *Hypothesis 2. Internal network support for a foreign multinational affiliate in an emerging economy can be positively related to technology adoption, but not technology creation.*

2.2.2 External network support and technology creation

In contrast to internal network support, research has consistently shown that formal and informal relationships *external* to the firm can be crucial for building, integrating, and combining knowledge for technology creation (Tortoriello, 2014). Core reason underpinning importance of

external ties is that information tends to be more homogeneous in groups rather than across groups (Kleinbaum & Tushman, 2007). An MNE therefore utilizes external contacts to absorb novel and diverse knowledge from the environment, and this in turn, will have a positive effect on its market performance (Andersson, et al., 2002). Indeed, the literature on networks often emphasizes that strong internal ties are related to knowledge exploitation whereas weak internal ties are connected with exploration (Nooteboom, 2000). Interactions with external partners may provide more novel insights with opportunities to benefit from a wider array of experience and expertise. Consequently, extant research has provided a significant amount of evidence indicating that webs of relationships reaching far outside the organization can facilitate finding valuable information as well as speed of internalizing that information as part of the firm's stock of knowledge (e.g. McEvily & Zaheer, 1999; Reagans & McEvily, 2003). Strong and long-term relationships with external agents, common R&D projects and collaborations, and customers and suppliers can be especially conductive for transferring complex and tacit knowledge. Indeed, intense contact and trust can mean more open feedback channels which can translate into more effective creation of new technologies (Andersson, et al., 2002). Thus, some of the most commonly cited benefits of external ties include attraction of new clients (e.g. through referrals) and development of new and innovative products and services based on information acquired through external networks (e.g. interesting emerging areas within a specific industry) (McEvily, et al., 2012).

In an *emerging economy*, external networks are often utilized to secure access to scarce resources and information, and to reduce environmental uncertainty in volatile and fast changing industries (Li, et al., 2008a). As the reliance and trust on institutions and market-based mechanisms are

relatively low, local firms often utilize inter-organizational networks for securing access to resources. In emerging economies and other institutionally risky environments, network ties are often built in order to facilitate mutually beneficial exchanges that might be too expensive to take place otherwise (Khanna & Rivkin, 2006). For instance, Siemens tightly cooperates with local universities in China due to access to engineering talent as well as testing facilities (Gassmann & Han, 2004). Alternatively, connections with local governments in China can provide access to funding and technical assistance for effective upgrading of products (Buckley, et al., 2006). In both cases, external networks are driven by resource-based reasons. Indeed, even the fact that an MNE has established R&D facilities is often considered evidence of long-term commitment to Chinese markets (Gassmann & Han, 2004).

Hypothesis 3. External network support for a foreign multinational affiliate in emerging economy can be significantly related to technology creation.

The conceptual framework is summarized in Figure 1.

<Figure 1 here>

3. DATA, MODEL AND METHODS

3.1 Research setting and data collection

We explore and test our hypothesis through primary data collected from Beijing, Chongqing and Jiangsu Province in China. To obtain required data we consulted the respective database of

foreign invested enterprises[2] (FIEs) from the Department of Enterprise Management of local Industrial and Commercial Administration Bureau (with which each enterprise has to register) in Beijing, Chongqing and Jiangsu Province in China. The databases contained the following firm-level information: name, address, start date of operation, industrial category, registered capital, ownership, number of employees, number of employees with at least college degrees, total and fixed assets, liability and turnover. There were 49,887 FIEs in the three regions in 2005. The databases allowed us to select a random sample, double check relevant firm information collected from a survey and test for non-response bias. Data from these three locations also allows us to capture different levels of development in China[3].

From the databases a sample of 1,223 FIEs was chosen following the systematic sampling method discussed in Guauri and Gronhaug (2009). We conducted a survey from May 2006 to January 2007. A draft questionnaire was first pre-tested via personal interviews with chief executive officers or other senior managers of 14 FIEs. This pretest allowed us to obtain insights into multinational affiliates in China, and provided an assessment of the questions' validity and the likely reliability of the data that will be collected (Saunders, et al., 2003). The questionnaire was then modified and finalized. The questionnaires were distributed by post. Telephone calls were made before and after the survey for the purpose of inviting people to participate in the survey and to check the reliability of returned questionnaires. The sampled affiliates were asked to provide information from 1999 onwards. Because affiliates were established in different years,

[2] A multinational affiliate is often called a foreign invested enterprise in China. Based on China's official definition, an FIE is a firm with 25% or more foreign ownership. This level of foreign ownership is to ensure foreign control.
[3] Beijing is the capital and one of the commercial centers of China. Jiangsu is a highly developed industrial and commercial region in China. Comparing with eastern regions, Chongqing is located in the southwest, and is relatively less developed.

our dataset is an unbalanced panel covering the period of 1999-2005. Given the reliability and validity issue associated with eliciting accounts of the past, we took steps to minimize the potential of retrospective bias by following advices from Miller, et al. (1997). We ensured that informants were someone very familiar with the multinational affiliates, therefore, were able to provide high quality information. Among the 1,223 FIEs, 493 questionnaires were returned with informants from 205 FIEs being the founders or chief executive officers, 188 chief financial officers and the rest senior human resource managers. We also motivated our informants to respond and to offer accurate information by ensuring confidentiality and providing them research results which would be potentially useful to the organization.

After thorough checking of returned questionnaires, 465 firms provided valid data for the purpose of this research, representing 38% response rate. Out of these 465 firms, 345 had at least 50% foreign ownership, and the remaining were minority foreign owned. We compared groupings of respondents with non-respondents according to registered capital assets. No significant differences were observed (t=-1.598, p>0.10), implying that *non-response bias is not* present in this study.

3.2 Model and Methods

To properly assess the relationship between technology adoption and creation, we need to develop a system of technology adoption and creation equations by incorporating internal and external business network support, as well as control variables, country-of-origin, regional, industry and time dummies. Our survey allowed us to use direct measures of technology

adoption (TA) and technology creation (TC), i.e. patents[4]. In the questionnaire, we asked two questions: (1) How many patents adopted in production are from the headquarters or other affiliates? (2) How many patents are self-developed? TA is measured by the number of patents developed and "owned" by the MNE group that were actually used by the affiliate. TC is measured by the number of patents developed and "owned" by the affiliate itself[5].

The key independent variables are an affiliate's internal and external business network support. Our measures drew from work of Andersson (Andersson & Forsgren, 1996; Andersson, et al., 2001b; Holm & Pedersen, 2000) and we follow a relatively well established method of asking a key manager to assess the extent to which specific types of relationships influence R&D and innovations (Andersson, et al., 2001b; Chiao & Ying, 2013). More specifically, for internal R&D support (or Internal Business Network Support, i.e. IBNS) senior managers in the affiliates were asked to answer the following question on a 5- point Likert-type scale with 1 indicating very helpful and 5 very unhelpful: "to what extent do the parent firm and other sister affiliates provide R&D support?". External R&D support (or External Business Network Support, i.e. EBNS) is related to the following question "to what extent, do local cooperative partners provide R&D support?"

[4] Using patent data has several advantages over other input measures such as R&D expenditure. This is because the latter do not reflect whether the acquired foreign technology has been internalized successfully and whether it has increased the recipient's technological capability. Firms may well have spent on the acquisition of technology, but fail to use it and integrate it to create new technologies. Hence, high R&D inputs do not guarantee the improvement of a firm's technological capability. On the other hand, there are some potential limitations to using patent data. First, not all innovations are patented or patentable. Second, the patent document usually contains extensive knowledge, while patent largely reflects codified knowledge not tacit knowledge. However, codified knowledge and tacit knowledge are closely linked and complementary (Mowery, et al., 1996). Therefore, the number of patents has been widely used as an important indicator for innovation (e.g. Almeida & Phene, 2004; Griliches, 1990).

[5] These measures are also vastly different from macroeconomic models examining technology adoption and creation (e.g. Basu & Weil, 1998; Parente & Prescott, 1994), which tend to use aggregate measures such as country's total factor productivity as a measure of technology adoption or creation.

Technology adoption and creation are determined by a number of factors. The existing literature identifies the following determinants of technology adoption and creation respectively: technological capabilities variables (human capital, tangible support assets and technology gap) (Driffield, et al., 2010; Kedia & Bhagat, 1988; Simonin, 2004; Stock, et al., 1996) and organizational variables (ownership form, foreign equity share and autonomy) (Belderbos, 2003; Desai, et al., 2004; Ghoshal & Bartlett, 1988), in addition to size (Belderbos, 2003; Tsai, 2001) and experience (Barkema, et al., 1996; Barkema & Vermeulen, 1998; Delios & Beamish, 2001; Young & Tavares, 2004). The individual measurement items for control variables are listed in Table 1.

<Table 1 here>

The following technology adoption and creation equations are established for empirical study:

$$(1)\quad TA = \alpha_0 + \alpha_1 TC + \alpha_2 IBNS + \alpha_3 JV + \alpha_4 For_equity + \alpha_5 Autonomy + \alpha_6 HC + \alpha_7 TSA + \alpha_8 GAP + \alpha_9 Size + \alpha_{10} Experience + \alpha_{11} Experience^2 + \gamma X$$

$$(2)\quad TC = \beta_0 + \beta_1 TA + \beta_2 IBNS + \beta_3 EBNS + \beta_4 JV + \beta_5 For_equity + \beta_6 Autonomy + \beta_7 HC + \beta_8 TSA + \beta_9 Size + \beta_{10} Experience + \beta_{11} Experience^2 + \delta X$$

Similar to a number of existing studies, we use both *Experience* and squared *Experience* to control for the impact of affiliate experience in the host market with the latter included to control for the possible diminishing effect associated with experience. **X** is a vector of dummy variables including country-of-origin, region-, industry- and time-dummies. The nationality of an MNE is expected to affect its affiliate's technology adoption and creation. For instance, developed

countries are the world's leaders of technology. Therefore, more technology adoption and creation are expected in multinational affiliates from developed countries than those from newly industrialized countries. The correlation between technology creation and technology adoption in affiliates may be affected by other factors such as fixed region-, industry- and time-specific factors such as infrastructure, technology opportunity and business cycles. To control for these fixed effects, we include region-, industry- and time-dummies. Data within the sample cover 26 industries according to the SIC classification at a 2-digit level across three regions and over the period of 1999-2005.

As development of patents do not follow a predictable pattern over time, a Poisson process that describes events that happen independently and randomly in time is suitable to estimate a function of patents (Hausman, et al., 1984). The probability that a patent (y_i) will occur given a set of explanatory variables $\mathbf{x}_i$ can be represented by the equation.

$$f(y_i \mid \mathbf{x}_i) = \frac{e^{-\lambda_i} \lambda^{y_i}}{y_i!}, \; y_i = 0, 1, 2, ...$$

However, the Poisson model needs to meet the requirement of equality between its first two moment conditions. Because of the unobserved effects, such as the uncertainty inherent in undertaking R&D or patenting, a problem of 'overdispersion' may occur, whereby the conditional variance exceeds the conditional mean. In this case, a negative binomial model can be used to overcome the problem. As shown in Table 2, the variance of technology transfer and that of technology creation are substantially larger than the corresponding means. The distribution of both variables is displaying a sign of overdispersion. Therefore, we present results from a negative binomial model.

<Table 2 here>

Because our data are of panel structure, the estimation procedure uses a random effects formulation to control for the unobserved affiliate-specific effect for two considerations. First, since variables such as entry mode, nationality and foreign equity share are constant within group, a fixed effects model, which focuses on year-by-year variation, would not produce the desired information. Secondly, a fixed effects model could produce noisy results when the explanatory variables are slow moving. Therefore, the use of the random effects model allows us to utilize the panel structure of our data set in a more efficient way.

Since there can be a bi-directional relationship between technology adoption and creation, we use the Wu-Hausman test to test for endogeneity of technology creation (adoption) in the statistical model of technology adoption (creation) in order to determine whether a simultaneous system of equations (1) and (2) should be estimated. This method is commonly utilized in strategy research to test for endogeneity between variables (Semadeni, et al., 2014). If there exists a two-way relationship, the estimation of individual equations for technology adoption and technology creation respectively will lead to biased results.

3.3 Common method variance

The collection of data from the same respondents at the same time can lead to the so-called common methods variance (CMV) which creates a false internal consistency (Chang, et al.,

2010). The potential for common method bias in this study is lessened because most of the variables used in this study are based on objective data which were corroborated with the information contained in the databases of FIEs mentioned earlier. There are only four focal variables, i.e. IBNS, EBNS, Autonomy and GAP, which are perceptual measures.

Nevertheless, we have performed Harman's one-factor test and partial correlation procedure to conduct validity checks and resolve the potential CMV issues (Podsakoff, et al., 2003). Harman's test consists of a factor analysis of all the variables of interest. If either a single factor emerges or one general factor accounts for the majority of the variance, a substantial amount of CMV is present. Accordingly, all the variables except country-of-origin, region-, industry- and time-dummies are entered into an exploratory factor analysis using unrotated principal-component factor analysis (PCA), PCA with varimax rotation and PCA with minimum average partial correlation criterion. On the criterion of eigenvalues greater than one, all three factor analysis methods reveal that four factors are extracted, none of which dominates. Unrotated PCA show that they together accounted for 72 percent of the total variance and the first (largest) factor accounts for only 28 percent of the variance.

Despite its popularity in addressing CMV, Harman's test is often considered to be inadequate (Chang, et al., 2010). We therefore have also tested CMV using a partial correlation procedure which partials out the first unrotated factor from the exploratory factor analysis. If this factor does not produce a significant change in variance explained in any of the dependent variables, it suggests that there is no sign of substantial CMV (Podsakoff, et al., 2003). In our case, after entering the first unrotated factor into the regressions, the results did not change much. Again the

partial correlation procedure provides further evidence that CMV does not account for the results we obtained in this study. In summary, the above analyses imply that CMV is an insufficient explanation for results.

4. EMPIRICAL RESULTS

As shown in Table 2, there are high correlations between JV and Foreign equity (*For_equity*) and between *Size* and Tangible support assets (*TSA*). To take into account multicollinearity, we present two sets of results which include either of JV and *For_equity* and either of *Size* and *TSA*[6] in Table 3. According to the Wald test statistics, the negative binomial panel regression with a random effects approach appears to fit both models well. The likelihood ratio (LR) test, a test of overdispersion, indicates that the standard Poisson distribution is inappropriate, justifying our use of a negative binomial model. The Wu-Hausman test for endogeneity suggests that there is an interactive relationship between technology adoption and creation, confirming the need to study technology adoption and creation in an integrated framework.

<Table 3 here>

We first look at TA and TC in specifications I & II. The coefficients on TA in TC equations are not statistically significant and the coefficients on TC in TA equations are positive and significant. This indicates that our hypothesis 1 is supported. Thus, technology creation in multinational affiliates in emerging economies heavily relies on technology adoption, but

[6] Different combinations of estimations are performed, the results are largely qualitative similar to what are presented in Table 3.

technology adoption does not relate to creation of new technologies. This is despite the fact that in China, R&D-related FDI inflows in China have surged in recent years, and up to 2004 about 700 foreign-R&D centers had already been established (UNCTAD, 2005, pp. XXIV).. In other words, facing resource scarcity and obsolescence in China, multinational affiliates according to our findings tend to be technology exploiting in that the technology and intellectual property are owned by parent company in developed economies. These affiliates are more motivated to carry out R&D that adapt technologies already existent in their respective MNEs rather than conduct their own original R&D to create new technologies. The use of existing technologies within MNEs still places them in a superior position in competing with local firms, and therefore does not significantly link to technology creation. After adopting technologies from the MNE, an affiliate needs to adapt them to the local or regional markets. In this process, the affiliate needs to possess or develop technical and engineering skills that are specialized in the technologies used in production, and this certainly facilitates affiliate capability enhancement. However, not all adaptive R&D leads to creation of new technologies, and the more the affiliate relies on technology adoption for its competitiveness in an emerging economy like China, the fewer new technologies it may create.

From Table 3, internal business network support (*IBNS*) is statistically significant in TA equations, but not in TC equations. Hypothesis 2 is supported. As discussed in section II, to learn, master and adapt technologies demands close and continuous interaction both internally with the rest of MNEs but also externally with the local environment. Since local firms face resource constraints and underdeveloped institutions in China, multinational affiliates have to rely more on the existing internal technology-based resources. Thus, internal network support

significantly influences technology adoption, which in turn, as we earlier theorized and empirically demonstrated, underpins technology creation. Of course, with local technological capability development, the focus of R&D will gradually shift from support and adaptation to full-scale R&D work using China's emerging technologies and talent pools (UNCTAD, 2005, pp. 166). At that stage, multinational affiliates based in China would play a greater role in knowledge creation and diffusion within MNEs' global innovation networks. This result hence strongly supports the notion that MNEs's provision of R&D support to their affiliates in China helps their adoption of the existing technologies, but not necessarily the creation of new technologies.

This closely links with our final hypothesis which predicted that external network support emphasizing radical new ideas not available within the firm would be needed for development of new technologies. However, the impact of external network (*EBNS*) on both TC and TA is statistically insignificant. Hence, hypothesis 3 is not supported. This interesting result is inconsistent with findings of Andersson and Forsgren (2000), Andersson, et al. (2001a) and Almeida and Phene (2004). Our first explanation for this surprising effect is based on RBV (Barney, 1991). As mentioned before, RBV proposes that firms with existing superior and inimitable resources and capabilities have lower level of dependence on external factors such and funding and technical assistance. These capabilities are then developed, combined, deployed and protected throughout the *internal* network of the MNE (Teece, et al., 1997). Even though external R&D support may be beneficial to the extent of identifying what technologies or capabilities could be utilized in the host country, multinational affiliates in China may not often have a significant need to invest in uncertain and costly networks with external partners for R&D

(Park & Luo, 2001). Indeed, previous studies have demonstrated that firms with high technological capabilities in general tend to emphasize technological independence rather than investing on forming networks with external actors (Prahalad & Hamel, 1990).

A second reason underpinning the insignificant relationship between external networks and technology creation might be the lack of heterogeneous but complementary skills, competences and capabilities in R&D at the local area (Cummings & Teng, 2003). Restricting collaboration to local searches can make it difficult to identify right firms and actors with necessarily level of skills and technical knowledge for developing new technologies or adopting old ones even in developed economies. Indeed, recent developments in social network theory have strongly emphasized that benefits of external ties are crucially dependent on these types of market-level factors (Tortoriello, 2014). It is also well recognized that knowledge integration process and knowledge exploration itself in China are often complicated by lack of trust between foreign and local firms and risk of appropriation (Fang, 2011).

Turning attention to control variables, we can see that human resources in multinational affiliates are more oriented towards technology adoption while tangible support assets are more towards technology creation. The internal technology gap variable (*GAP*) is statistically significant with positive sign, indicating that the MNE's strategy for technology adoption is more often based on its recognition of the internal technology gap. "JV" is statistically significant in both TA and TC equations, but with different signs, revealing that, being in a joint venture helps with technology creation, but negatively affects technology adoption (or technology transfer). This latter result is consistent with Deng (2001) who notes that a large number of foreign invested firms in China

have chosen wholly-owned subsidiary over joint venture in order to avoid the possibility of loss of control over proprietary technology and know-how and long-term competitive advantages. Foreign equity share (*For_equity*) is positive in the TA equation and negative in the TC equation. This implies that, with foreign equity share increasing, a multinational affiliate will be more willing to receive and rely on new technologies from its parent (so will be the parent to transfer them) as high equity share increases the control of proprietary technology by the foreign partner. *Autonomy* appears to be insignificant in both equations. One possible explanation is that, although multinational affiliates are assigned autonomy by their parents, possibly because of the Chinese culture, the affiliates are not good at taking initiative[7] to make best use of the decision-making power in order to be actively engaged in technology adoption and creation. Technology transfer (or technology adoption) decisions may be still largely made by the headquarters. Size is statistically insignificant in the TA equation, and is positive and statistically significant in the TC equation. We do not think that the results are a surprise as the empirical studies have so far provided mixed results on the relationships between affiliate size and its technology adoption and creation. Similar to a number of existing studies, we use age to control for the impact of affiliate experience in the host market. It appears that, when the affiliate grows older, there is less technology adoption, but more technology creation. However, the negative effect of experience on technology adoption and the positive effect of experience on technology creation do diminish over time.

[7] As defined by Birkinshaw (2000), affiliate initiative is 'undertaken with a view to expanding the affiliate's scope of responsibility' (p. 8).

5. CONCLUSIONS

Technology adoption and creation in overseas affiliates are essential for MNEs to enhance their competitiveness in the global market. These two important phenomena have been investigated in separate studies, so that little is known about how they interconnect in the context of an emerging economy. The paper aims to fill in this research gap. From a perspective of the RBV, we argue that the nature of the relationship between technology adoption and creation by multinational affiliates in an emerging economy is different from that in a developed one. An emerging economy is characterized by constrained resources, underdeveloped factor and product markets and underdeveloped but rapidly changing institutions. Multinational affiliates in an emerging economy tend to focus more on technology adoption than creation, and technology adoption is a necessary condition for technology creation. This was our first hypothesis. As networks are particularly essential for substituting a weak institutional environment in the context of an emerging economy, our second and third hypotheses focused on internal and external network support.

Our hypotheses were tested based on data collected from 465 multinational affiliates in China for the period 1999-2005. The hypothesis on the relationship between technology adoption and creation was supported. Technology adoption can discourage technology creation in a multinational affiliate based in an emerging economy, as this places the affiliate a superior position relative to local firms. Even if technology creation is required, the affiliate would still seek from its MNE technology-based resources which are unavailable an emerging economy. As a result, technology creation will lead to further technology adoption. Different from a developed

economy, the reinforcing effect from technology adoption to technology creation can be relatively weak in an emerging economy. In terms of the other two hypotheses, while tight internal linkages were shown to be significantly related to technology adoption rather than creation, no relationship was found between external networks and technology creation or adoption. These findings further emphasize multinational affiliates' reliance on internal R&D support and lack of reliance on external partners in making improvements on its technological level as an emerging economy is as usually a technology follower.

There are limitations to our study. First, we rely on patent data reported by senior managers. Unfortunately we do not have access to China's patent database which might be a more reliable and objective source. Second, the dataset is limited to China. It could be that an affiliate's technology adoption and creation partly hinge on the MNE's country-specific advantages (Rugman & Verbeke, 2001), and therefore different results could be obtained, for example, from Brazil. A comparative study of affiliates across different countries would be an interesting future research avenue considering the increasing research focus on both bridging across diverse pockets of knowledge (Burt, 2004; Tortoriello, 2014) and HQ's ability to manage subsidiary relationships for innovation processes (Ciabuschi, et al., 2014; Forsgren, 2008). In addition, future studies could further elaborate the mechanism underpinning why and how internal network support may not be related to technology creation in an emerging economy context. Could it be the result of a direct mandate, lack of appropriate internal support, or difficulties involved in supporting affiliates in that context? Related to this, another limitation is that we do not have detailed information about the parent companies. As a result, we could not assess the role of the overall structure of the MNE in shaping its affiliates' strategies and activities as we

observed. Untangling these mechanisms will be helpful in pushing the boundaries of RBV, institutional voids, and innovation literatures in the emerging economy context.

These limitations aside, the current research bears policy and managerial implications. Our findings suggest that multinational affiliates in an emerging economy are more technology exploiters than creators. Knowledge flow is mainly one-way from the MNE to its affiliates, a pattern of technology adoption, creation and diffusion not very conductive to the competence development of the whole MNE. To promote economic development, emerging country governments can first facilitate multinational affiliates to create technologies locally for the MNE's global innovation network. Emerging country governments need to improve their social, economic and political institutions such as education and R&D support (e.g. increased R&D expenditure), increase incentives to conduct R&D, make better use of science and technology parks and enhance IPP. This helps emerging economies to improve their human resources and technological capabilities and move towards the international technological frontier. This will encourage MNEs to conduct more advanced innovative activities and will further enhance local capability development. For example, China is now already one of the worlds' top ten leading economies in R&D expenditure (UNCTAD, 2005, pp. 105), and further government support will certainly accelerate China's technology upgrading.

In order to achieve technological advantage over competitors, this paper underscores that in combination with R&D support network characteristics of the firm, managers need to carefully balance resources for technology creation and adoption. First, our finding on technology creation and technology adoption implies that successful adoption of existing technologies requires

adaptive R&D. We should note that the relatively intuitive link between technology adoption and creation is moderately weak in an emerging economy context. Consequently, to emphasize R&D driven by local markets, multinational affiliates require a relatively high degree of autonomy. This is consistent with recent findings of Tian and Slocum (2014) who found that performance of multinational affiliates in China is driven by strategic initiatives in line with the host environment. Even though adaptive R&D is still risky from an IPP perspective, these risks are, to some extent, manageable in an emerging market context (e.g. through anti-piracy strategies) (Yang, et al., 2008). While we found no support for the positive relationship between external networks and technology creation, we posit that fostering these relationships at personal, regional, and national levels is still crucial for obtaining accurate and up-to-date information and training on IPP issues. With rapid improvement of technological capabilities in emerging economies such as China, MNEs' external networks in these economies will soon have a positive impact on MNEs' technology creation. It should be noted that, as demonstrated in previous studies (e.g. Cantwell & Mudambi, 2005), the degree of affiliate autonomy changes according to different stages of R&D internationalization. Therefore, managers may initially prefer a higher degree of control and limit the amount of original research until the affiliate is more familiar with the local intellectual property regime.

Second, with an emerging economy improving its technological capabilities, MNE managers may need to encourage their affiliates to conduct more innovative R&D for the international market using relatively low-cost talent pool in that economy. Multinational affiliates need also take an initiative to play an active role in technology adoption, creation and diffusion within MNEs. By so doing, an MNE can act more like a global knowledge network by tapping into

technology-based resources from emerging as well as developed economies.

Third, the fact that internal R&D support was found to be strongly linked to technology adoption (rather than creation) has important implications for forming intra-firm networks. Organizational practices could, for example, emphasize reimbursing employees for being active in various intra-firm projects and serving on different committees. Providing rewards and evaluating employee performance based on building strong relationships and diffusing knowledge could also act as mechanisms which could potentially stimulate, according to the findings of our study, utilization of both new and old technologies. Furthermore, consistent with previous research on foreign R&D in China (e.g. Von Zedtwitz, 2004), we propose that staffing decisions should emphasize directors with holistic knowledge of the firm's internal operations and key influencers and decision-makers; especially in the case that the firm's strategy places greater emphasis on technology adoption rather than creation. In practical terms, R&D managers (whether local or international) should rotate through the most important departments in the headquarters and within the MNE in order to become familiar with operations and form strong relationships with key actors (Cooke, et al., 2014). Indeed, a great deal of research has addressed dissemination of knowledge through global teams, expatriates, training, and mentoring, and our results indicate that internal networks are crucial for technology adoption. Similarly, cross-cultural training and bridging the cultural gap will enable managers to more effectively manage their intra and inter-firm relationships and absorb local skills and knowledge.

In summary, there will be no either/or solution for balancing technology adoption and creation for multinational affiliates. MNEs should focus on aligning corporate and business level R&D

strategies so that their affiliates in emerging economies can effectively evaluate institutional voids and resources involved in technology creation and adoption within and across companies over time. The Chinese market provides an excellent study context because simultaneous adoption and creation of technology may be to a great degree influenced by the institutional context. However, it should be recognized that specific formal and informal institutional characteristics may vary greatly within and between countries (e.g. institutional legacies of a planned economy like China vs. other forms of Asian capitalism (Carney, et al., 2009)). Similarly to other scholars working on emerging economies, we are acutely aware of the institutional context in explaining our key phenomena, and wish to avoid over-generalization (for a recent review on international business research on emerging economies, see Meyer and Peng (2016)). Nevertheless, this paper contributes both theoretically and empirically to our understanding of the behavior of technology adoption and creation of multinational affiliates in an emerging economy, as it has developed and tested a conceptual framework using a unique panel data set of multinational affiliates in the world's largest emerging economy.

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Table 1: Variable Measurements

Variable	*Description*
1. Technology Creation (TC)	Number of self developed patents
2. Technology Adoption (TA)	Number of patents adopted from the parent and sister affiliates
3. Internal Business Network Support (IBNS)	"To what extent do the parent firm and other sister affiliates provide R&D support?" 5 = Very helpful…, 1 = Very unhelpful.
4. External Business Network Support (EBNS)	"To what extent, do local cooperative partners provide R&D support?" 5 = Very helpful…; 1 = Very unhelpful
5. JV	1 = joint venture; 0 = wholly owned affiliate
6. Foreign equity (For_equity)	Share of foreign equity in the affiliate
7. Autonomy	"Who makes decision on affiliate's R&D?" 1 = the affiliate; 0 = the parent makes decision.
8. Human capital (HC)	The number of employees with at least college degree ('000)
9. Tangible support assets (TSA)	log(Affiliate's R&D expenditure)
10. Technology gap (GAP)	"What is the technological level of the affiliate relative to the parent and other sister affiliates?" 1 = very advantageous, …, 5 = very disadvantageous.
11. Size	log(fixed assets)
12. Experience	Number of years of operation up to 2006

Table 2: Descriptive Statistics and Correlation Matrix

Variables	*No. of obs.*	*Mean*	*Standard deviation*	*1)*	*2)*	*3)*	*4)*	*5)*	*6)*	*7)*	*8)*	*9)*	*10)*	*11)*
1) TC	2382	2.731	10.066	1										
2) TA	2380	3.670	11.893	0.764	1									
3) IBNS	2379	4.201	0.734	0.153	0.240	1								
4) EBNS	2380	3.649	0.600	0.034	-0.052	-0.152	1							
5) JV	3451	0.613	0.487	-0.093	-0.142	-0.060	0.464	1						
6) For_equity	3451	67.163	29.003	0.072	0.140	0.146	-0.462	*-0.872*	1					
7) Autonomy	2379	0.695	0.460	-0.095	-0.153	-0.335	0.193	0.106	-0.154	1				
8) HC	2381	0.105	0.195	0.456	0.547	0.215	0.048	0.015	-0.011	-0.119	1			
9) TSA	2131	5.369	2.021	0.270	0.349	0.315	0.160	0.051	-0.020	-0.056	0.611	1		
10) GAP	2379	3.326	1.064	-0.084	0.093	0.513	-0.258	-0.040	0.147	-0.378	0.099	0.045	1	
11) Size	2375	6.861	2.046	0.330	0.421	0.295	0.129	0.083	-0.054	-0.095	0.663	*0.853*	0.067	1
12) Experience	2207	5.714	3.597	0.069	0.007	-0.104	0.120	0.198	-0.198	0.154	0.086	0.112	-0.146	0.192

Note: Variables are defined in Table 1.

Table 3: Negative Binomial Panel Regression

			(I)		*(II)*
Variable		*Technology adoption (TA)*	*Technology creation (TC)*	*Technology adoption (TA)*	*Technology creation (TC)*
Technology creation	(TC)	0.784**		0.746**	
		(0.144)		(0.122)	
Technology adoption	(TA)		0.037		0.268
			(0.196)		(0.166)
Internal Networks	(IBNS)	0.463**	0.050	0.499**	-0.070
		(0.056)	(0.113)	(0.059)	(0.112)
External Networks	(EBNS)		-0.004		-0.018
			(0.055)		(0.053)
Technology capability	(HC)	1.065**	-1.395**		
		(0.237)	(0.351)		
	(TSA)			0.013	0.322**
				(0.062)	(0.066)
	(GAP)	0.137**		0.126**	
		(0.035)		(0.036)	
Entry Mode	(JV)			-0.489**	0.920**
				(0.171)	(0.222)
Foreign equity share	(For_equity)	0.012**	-0.014**		
		(0.003)	(0.004)		
Autonomy	(Autonomy)	-0.029	0.039	0.036	0.076
		(0.053)	(0.066)	(0.053)	(0.067)
Size	(Size)	-0.070	0.532**		
		(0.094)	(0.103)		
Experience	(Experience)	-0.113**	0.074*	-0.112**	0.102**
		(0.021)	(0.037)	(0.023)	(0.029)
	$(Experience)^2$	0.002*	-0.002†	0.002†	-0.002
		(0.001)	(0.001)	(0.001)	(0.001)
Diagnostic tests					
Wald		624.33**	472.24**	591.640**	495.650**
LR		1353.40**	1552.33**	1532.250**	1584.130**
Wu-Hausman		29.51**	0.03	37.340**	2.620

Notes: Robust standard errors are in parentheses. †, *, ** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Country-of-origin, regional, industry and time dummies are included in the analyses. The omitted dummies are: wholly owned subsidiaries, affiliate has no autonomy in R&D decision making, and MNEs from other countries than US, Japan, Canada, Australia and EU. Wu-Hausman statistics test the endogeneity of technology creation and technology adoption in relevant equations.
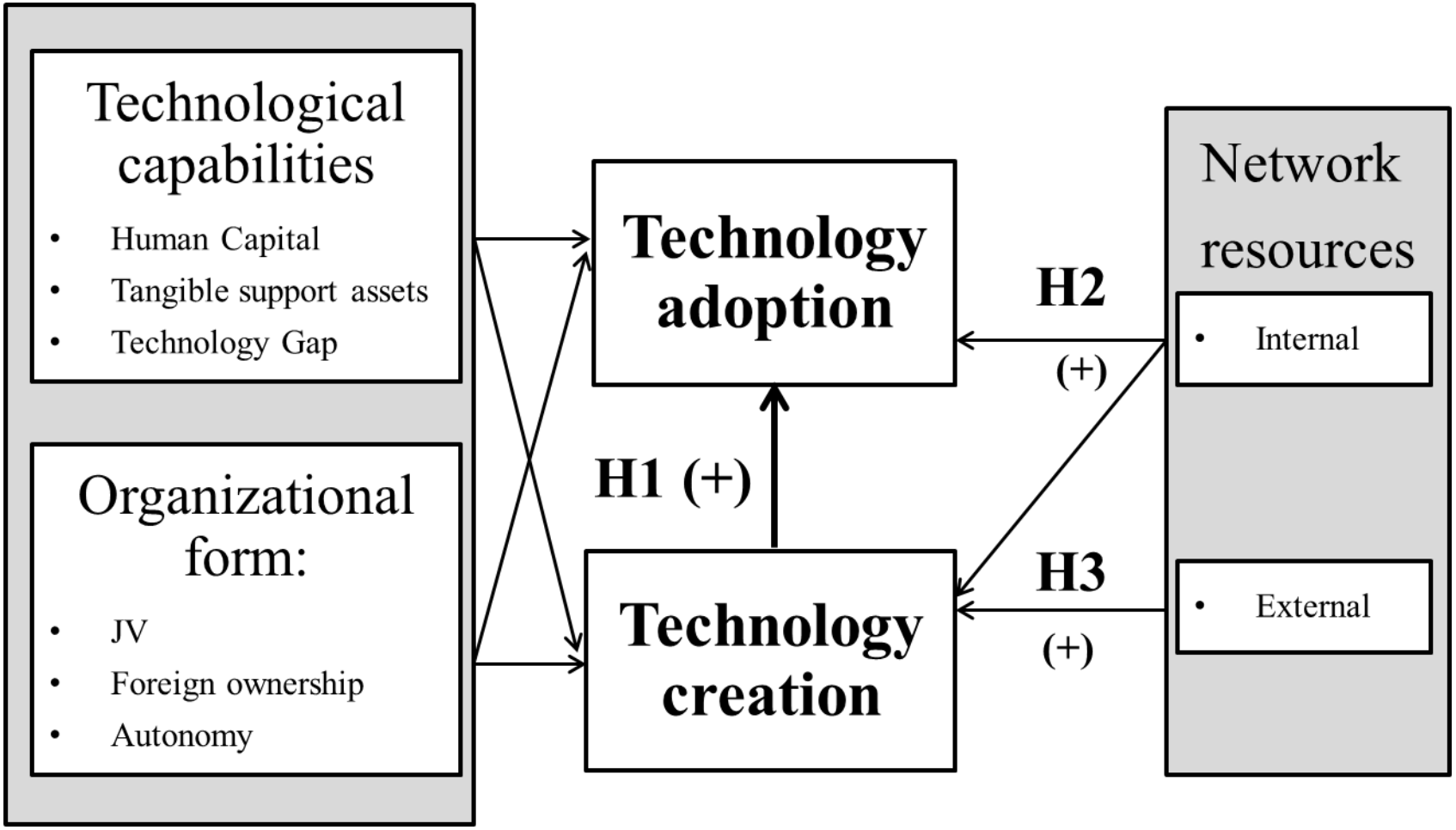
Figure 1 Conceptual Framework