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Technology transfer within China and the role of location choices

Abstract

We examine how emerging country business groups overcome various technological constraints and succeed in enhancing their performance. Our theoretical contribution lies in showing how the ability of a business unit to benefit from intra-group technology transfer depends on the idiosyncratic manner in which the group geographically configures its network of units. The findings reveal that the geographic dispersion and concentration of the units of a group alter both the ability and willingness of its business units to transfer technologies to (or receive technologies from) other units and subsequently result in different performance outcomes. The location of a business unit also determines whether or not a unit competes with other fellow units and, consequently, influences how much a unit benefits from the technologies held by the group.

Keywords: technology transfer, China R&D, spillovers, operational performance, cities, networks

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1. Introduction

Although emerging market enterprises (EMEs) do not typically possess strong R&D capabilities, they have recently become an integral component of the global technological system (Mudambi, 2008; Wang and Zhou, 2013). While this phenomenon opens up new avenues for theory development in international business and management, we have a limited understanding of how EMEs overcome various constraints and succeed in enhancing their performance. Research about developed countries considers technology to be one of the most important determinants of firm competitiveness and performance, but many firms in emerging economies do not possess and cannot quickly develop such technologies. Research on emerging markets suggests that some EMEs can compensate for such shortcomings by being part of a business group – i.e., organizations that own and control two or more business units (Khanna and Palepu, 1997). From a technological point of view, one of the key benefits of being part of a group is organizational learning. Each business unit is part of an integrated and interactive network of fellow units and can source knowledge and technology not only from the market but also from fellow units in the same group (Macher and Mowery, 2009; Szulanski, 2000, Tsai, 2001).

Business units that belong to groups are in a unique position to access the technologies developed by other units of the same group, but transferring and integrating spatially distributed technical knowledge can be a disruptive and challenging process (Gupta and Govindarajan, 2000; Kafouros and Buckley, 2008; Kasper et al., 2013). As a result, technology transfer may not be equally beneficial to all the units of a group. Although prior research has emphasized the importance of a unit's capacity to absorb knowledge (Tsai, 2001), much less attention has been focused on the location of units and the geographic distribution of the group's network of units. From a theoretical point of view, this significantly limits understanding of how the location of a unit influences its ability to gain useful technology from fellow units and, subsequently, enhance its performance.

In order to address this gap in our understanding, in this study we examine how emerging economy business groups locate and geographically structure their network of units, and how such variations influence the effectiveness of intra-group technology transfer in enhancing the operational performance of business units (i.e., the efficiency with which a unit uses a given set of resources to create certain outputs; Dutta et al., 2005). Our theoretical contribution lies in demonstrating why the ability of a business unit to benefit from the collective knowledge and technologies of the group depends on the idiosyncratic manner in which the group geographically structures its network of units. We show that the operational performance of a business unit depends not only on its own location but also on the location of its fellow units. We also explicitly consider and capture the exact locations (i.e., cities) of the group's entire network of units, which in turn enables us to examine how location choices influence knowledge dependencies within the group.

To test our predictions, we need an emerging country that is innovative and exhibits significant geographic variation. We therefore focus on one of the largest, most diverse and innovative emerging countries in the world: China. We conceptualize each Chinese group as an interactive network or portfolio of geographically dispersed business units (Gupta and Govindarajan, 2000). We observe that groups differ in how widely they spread their units across different cities and in the degree to which they concentrate units in each city (some groups locate several business units within the same city while others locate only one unit). To capture these variations, we look at the geographic dispersion of the units of the group (network breadth) and the concentration of the group's business units in each given city (network concentration). These two aspects of a group's network of units are not always negatively associated, i.e., a group may be dispersed and operate in several cities but may also have several units located in the same city. Fellow business units often develop comparable products or invest in similar technologies (Birkinshaw and Lingblad, 2005). As a result, they often compete with one another and are not always willing to share knowledge with other units. We argue that variations in network breadth and concentration change the potential for collaboration and competition within the group, affect both the ability and willingness of units to transfer knowledge to (or receive knowledge from) fellow units and, thereby, have a profound impact on the operational performance of each individual unit.

Our analysis extends prior theorizing on the role of knowledge transfer by explaining why the performance-enhancing effects of technology transfer are contingent both upon the way in which groups in emerging countries configure their portfolio of business units, and the location of the unit in relation to that of fellow units. Given our focus on emerging countries and subnational variations at the city level, in this study we are concerned with groups that are uni-national. Although we do not consider multinational groups, some of the predictions of our framework could be adapted to firms that own business units abroad or to groups that operate in developed markets. Our focus on uni-national firms enables us to look more closely at cities (which are often ignored in international business studies that examine cross-country networks) and investigate how intra-firm network mechanisms function spatially within one country. Our approach also extends the clustering and co-location literatures by demonstrating that merely participating in clusters or achieving proximal access to a knowledge-rich location is not sufficient for enhancing firm performance. Rather, we show that the way in which the firm distributes its business units relative to the unit in question determines whether this unit benefits from being located in a certain area, and whether the whole group benefits from positioning its units in a given way.

2. Theoretical Background

Before developing specific hypotheses, the next sections provide a theoretical overview of the role of business groups in China, and how they may increase their performance by transferring knowledge and technology. They also discuss the dynamics of collaboration and competition within business groups, and how such dynamics are influenced by variations in location choices.

2.1 Business groups in China

A large body of research explains how market imperfections and underdeveloped institutions in emerging countries, such as China, give rise to business groups (e.g., Leff, 1978; Khanna and Palepu, 1997). Business groups can overcome institutional voids and market failures by relying on the group's internal capital market and talent pool, by building intangible assets such as strong group reputation and brand names, and by accumulating expertise and knowledge from different affiliates operating in various locations (Belenzon and Berkovitz, 2010; Chang and Hong, 2000; Gopalan et al., 2007; Jian and Wong, 2010; Keister, 1998, 2001; Khanna and Palepu, 2000; Khanna and Rivkin, 2001; Mahmood and Mitchell, 2004). The literature points to the performance advantages that emerging market business groups enjoy compared with other firms (e.g., Mahmood et al., 2011; Manikandan and Ramachandran, 2014). It also underscores the different ways in which knowledge is accumulated and assimilated within these business groups, and the non-monotonic process of intra-group knowledge transfer (e.g., Mahmood et al., 2011).

Chinese business groups function as an alternative (and more efficient) market to facilitate the transfer of resources including capital and knowledge among units of the same group (Nan et al., 2013). Business groups in emerging markets enjoy considerable advantages. Institutional voids in emerging markets (Manikandan and Ramachandran, 2014) result in a lack of low cost options and coordinated efforts in the external market to facilitate the innovation process. For example, firms that do not belong to business groups may find it difficult to conduct both local and distant search (Haakonsson et al., 2013) while the weak appropriability regime in these markets reduces the chances of creating competitive advantages through innovation (Bradley et al., 2012; Keupp et al., 2012). Groups can also deal with underdeveloped capital markets (Mahmood and Mitchell, 2004) by being able to finance the development and commercialization of new innovative ideas, and increase the benefits of sharing resources among affiliates (Mahmood et al., 2011; Nan et al., 2013), thus helping groups to enhance their overall performance.

2.2 Technology transfer within business groups

Knowledge is unevenly distributed not only across countries but also within sub-national geographic areas (Breschi and Lissoni, 2009, Kloosterman, 2008). Consequently business groups can tap into the knowledge of different regions and cities through the local operations of their units. The technological knowledge that a unit can access in one region can be transferred internally to other units of the same group in different regions. Theoretical insights from the innovation literature suggest that the technologies created in units within the group may help fellow research and development (R&D) business units to complement their own technical knowledge base, develop new or better products and processes and, thereby, enhance their capability and performance (Ebersberger and Herstad, 2012; Kafouros, 2008; Lai et al., 2010; Macher and Mowery, 2009). Two distinct mechanisms (namely, intentional technology transfer and unintentional spillovers) may assist a business unit in benefiting from the technologies developed within the group. The first mechanism occurs when corporate headquarters (HQ) encourage, or even force, their business units to share technological discoveries with fellow units. This practice facilitates organizational learning within the group as a whole that in turn enhances the innovation performance of all units (Kogut and

Zander, 1992; Tsai and Ghoshal, 1998; Tsai, 2001).

Because business units that operate in different locations have access to a different knowledge pool (Kafouros et al., 2012), the technologies developed by each business unit often differ from one another. Therefore, a unit's knowledge may complement the knowledge base of fellow units, enabling them to develop valuable technological combinations (e.g., Abecassis-Moedas and Mahmoud-Jouini, 2008; Lai et al., 2010). As a business unit learns from fellow units, it accumulates a stock of technological knowledge that assists the unit in developing new products and processes and in enhancing its performance. Various channels including intentional employees' mobility (e.g., the transfer of engineers from one department to another) facilitate the flow of tacit knowledge, resolve problems and improve performance (Breschi and Lissoni, 2009; Macher and Mowery, 2003).

The second mechanism through which business units may benefit from the technologies developed within the group involves unintentional knowledge spillovers. Even when the HQs do not encourage technology transfer, the units of the group might still be able to benefit from the group's knowledge, and access the knowledge of other units, through informal channels such as the self-chosen mobility of employees and social networks of scientists and engineers. For example, social interaction enhances the absorptive capacity of the unit as it enables individuals to transform new knowledge to suit new contexts and to develop unique applications (Hotho et al., 2011). Hence, the benefits and value of new technology may not be solely captured by the inventing unit but may, instead, spill over to others. Several studies document the existence of such knowledge spillovers (e.g., Breschi and Lissoni, 2009; Lo and Chung, 2010; Kafouros et al., 2012), showing that the existence of specialized complementary assets within individual units creates technological synergies within the group (Lai et al., 2010).

Intra-firm spillovers also enhance firm performance by influencing organizational learning and intra-firm technological diffusion (Fuentelsaz et al., 2009). As units gradually adopt technologies, they improve their capabilities, reduce costs and increase their output. Furthermore, because each unit often possesses a diverse set of skills and competences, intra-firm knowledge spillovers may help forge new technological avenues and develop more efficient organizational routines. Hence, regardless of the manner of the technology transfer mechanism (intentional or unintentional), business units may enhance their capabilities and performance by accessing knowledge and technologies developed by other units of the same group. In practice, both intentional and unintentional technology transfer co-exist since organizational learning takes place at various levels and in various technological dimensions.

2.3 Competition within business groups

Although business groups do not often duplicate investments, their operations at the business level are not perfectly differentiated. This may give rise to competition among units of the same organization and, under certain conditions, one unit can negatively affect the performance of other units in the same group. Intra-firm competition arises when the business units of a group produce competing products, try to solve similar technological problems, or serve the same market segment (Birkinshaw and Lingblad, 2005). Moreover, to create strategic options and increase market coverage, multi-unit businesses often organize their units in a way that encourages competition (Kalnins, 2004). A business unit may negatively impact the performance of fellow units by affecting their innovative efforts and operations.

First, business units may compete with each other in the same market as they often offer products that are partially interchangeable (e.g., Bartlett and Ghoshal, 1993; Rumelt, 1974; Tsai, 2002). Groups often face environmental uncertainty and ambiguity in defining the exact technological position of the group in one or more industries (Birkinshaw and Lingblad, 2005). In other situations, the HQs encourage units to develop competing products and technologies in order to maximize the chance of identifying and exploiting a range of profitable opportunities (Birkinshaw and Lingblad, 2005; Taylor, 2010). In responding to rapid technological change, groups may also encourage their units to pursue different business models (Ter Wal, 2013) and technological trajectories; for instance, units might work to different technology standards (Birkinshaw and Lingblad, 2005). Business units that operate in highly heterogeneous markets may also offer a large variety of products that enable the group to closely serve each segment (Birkinshaw and Lingblad, 2005). Intra-firm competition also arises due to decentralization of decision making. In such situations, business units choose the product markets they want to pursue without interference from the group (Birkinshaw and Lingblad, 2005; Burns and Stalker, 1961). When two units decide to focus on the same product market, intra-firm competition often leads to situations where one unit increases its market share and performance at the expense of a fellow unit.

Second, while the R&D conducted by a unit contributes to the pool of technologies of the entire group, it also enhances that unit's own products, processes and competitiveness. The innovation literature suggests that the positive consequences of knowledge spillovers are confounded with negative market-stealing effects (Aitken and Harrison, 1999; McGahan and Silverman, 2006). In a business group, when units try to solve similar technological problems or work on technologies that can be used as substitutes for one another, the technologies developed by one unit may increase its own output and capabilities but have a negative spillover effect on other units in the group (Kafouros and Buckley, 2008).

Third, business units compete with one another for tangible and intangible resources allocated by the HQs. Because such resources are limited, units obtain new assets at the expense of fellow units, and superior technology is a currency through which a unit can gain bargaining power and strengthen its position within a corporate group (Gupta and Govindarajan, 2000). By contrast, a unit may lose R&D resources as star scientists and engineers go to the research labs of fellow units. Thus, a higher stock of knowledge and technologies may further enhance the performance of some R&D-intensive business units, but decrease that of other units of the group.

Negative competition effects also arise when the HQs encourage knowledge sharing and collaboration between its units by offering various incentives to managers (Martin and Eisenhardt, 2010; Zenger and Hesterly, 1997). Although this strategy improves knowledge flows, when two units compete in similar product markets, they become sensitive to the HQ's interference and refrain from sharing their knowledge with fellow units (Tsai, 2002). While the HQ tries to create synergies through knowledge transfer (Gupta and Govindarajan, 1986; Kasper et al., 2013), it also allocates resources to units according to their performance (Mudambi and Navarra, 2004; Stein, 1997). This, in turn, encourages units to protect their knowledge and technologies from fellow units.

2.4 Spatial agglomeration and geographical configurations of business groups

Another important dimension of geographical configuration is spatial agglomeration. Economies of agglomeration enable firms to benefit from locating near each other because of a larger supplier and customer base, the availability of talent and localized knowledge spillovers (Rosenthal and Strange, 2004). Diseconomies may also arise from agglomeration, as limitations of urbanization, such as congestion and diminishing returns as a result of increased competition among businesses in the same field, reduce the overall benefits of spatial concentration (Mayer, 2013). Taking these dynamics into consideration, a group may choose to spread its units among several urban areas or concentrate its units within a certain location.

Intra-group knowledge transfer and competition therefore will depend on the interaction between the way in which a group configures its units and the mandates of these units when located in a specific location (i.e., whether the resulting relationships between units in a given location are vertical or horizontal). For example, when a group spreads its units among highly differentiated locations, competition among units will be low because the performance, technologies, and bargaining power of the unit in this given location are shaped differently from those of units that are located in other clusters. This will thus affect the willingness and ability of the units in these locations to transfer knowledge. In summary, spatial agglomeration may drive business groups to configure their units in a manner that exploits location specific knowledge and opportunities. This may have a profound impact on the performance of each unit because, as we discuss in the next sections, it influences the resulting linkages between units as well as the willingness and ability of a unit to transfer knowledge within the group.

3. Conceptual Framework and Hypothesis Development

The previous section demonstrates why the technology created within a group may have both positive and negative implications for the performance of a business unit. In this section, we employ a contingency perspective to explain under what conditions the positive effects are likely to exceed the corresponding negative consequences. Given our focus on location, we develop the premise that the geographic configuration of a group's network of business units influences both the ability and willingness of a unit to transfer technological knowledge to other units and, thus, may result in different performance outcomes. As discussed earlier, our analysis rests upon two key sources of variation that reflect the different ways in which groups may geographically distribute business units. Network breadth refers to the geographic dispersion of the units of a group within a country and can be measured by looking at the number of cities in which the group operates and the diversity of their locations country-wide. Network concentration captures the concentration of a group's business units in each given city. The higher the number of business units that a group has in a given city, the higher the level of network concentration. The two constructs therefore reflect differences in the geographic scope and scale of the operations of the groups. The next sections discuss the role of network breadth and network concentration in detail, and Figure 1 summarizes the theoretical framework and hypotheses.

Insert Figure 1 here.

3.1 Network Breadth

We propose that variations in business unit performance result from differences in the breadth of a group's network or portfolio of business units. Innovation is a function of the knowledge sources accessible to the firm (Lo and Chung, 2010). The chances of inventing valuable technologies and products increase when the organization has the opportunity to build on a variety of complementary pools of knowledge (Lai et al., 2010; Leiponen and Helfat, 2010; Lo and Chung, 2010), and much of such knowledge is localized in cities. This can be observed at a macro-level through the contribution of human capital, knowledge and skills to a city's growth (Florida et al., 2012), and at a micro-level through the diffusion of tacit knowledge bridged by links with local institutions and the labour pool (Kloosterman, 2008).

Groups with higher network breadth locate their units in various cities. As knowledge is location specific (e.g., Hotho et al., 2011; Tallman and Phene, 2007), units that operate in different locations can access and accumulate knowledge of several domains, with varied specificity and contextual applications (e.g., Wood and Reynolds, 2012), and exploit potential spillovers arising from economies of agglomeration and add new elements to their knowledge base. Thus, network breadth gives business units the opportunity to access a wide range of knowledge sources from diverse markets, scientists, and other local talent pools that can be uses to improve performance.

This view is consistent with the international business theory that suggests that geographically diversified firms enjoy higher returns from innovation (Caves, 1982). Network breadth may enable groups to use their distributed units to accumulate various resources, and to create diverse teams with complementary skills. Reinforcing this premise, other studies suggest that business groups use their units in order to achieve proximal access to knowledge resources, access knowledge from several locations and clusters, and transfer knowledge across business units (Coe and Lee, 2013; Ebersberger and Herstad, 2012; Kafouros et al., 2012). Studying the evolution of collaborative innovation networks, Ter Wal (2013) suggests that there is a growing tendency for innovators to collaborate with distant partners as the degree of appropriability increases. In other words, the internal sharing of knowledge-generating activities over a wider geographical area enables innovators to reduce negative factors associated with their innovative activities. Hence, a network of geographically dispersed business units may mitigate the risk and uncertainty associated with innovation as such networks help the group balance any deficiencies or fluctuations specific to a location. It may further facilitate the development of new capabilities and improve performance within the group by increasing operational flexibility (Tang and Tikoo, 1999).

In contrast to the above arguments, however, the opposite effect may arise when network breadth is particularly high; i.e., a higher breadth level may negatively influence the effects of intra-group technology transfer. Increasing geographical space between units can weaken the ability of a unit to learn from others. Learning requires the opportunity for a person or a unit to watch another person or unit perform a task (Nadler et al., 2003), the opportunity to obtain answers to various questions when searching for relevant knowledge (Borgatti and Cross, 2003), the participation of individuals in social interaction in order to integrate knowledge locally (Hotho et al., 2011), and the ‘dynamic relatedness’ assisting the spread of complementary assets and the coordination of learning and problem solving among units (Lai et al., 2010). Thus, despite business groups' efforts in improving communications between units (e.g., Macher and Mowery, 2009), high levels of network breadth reduce the physical and psychological proximity needed when transferring technological knowledge.

Moreover, although high levels of network breadth may assist the firm in accessing knowledge, it may not always be able to benefit from such knowledge. Integrating distributed knowledge can be challenging and time consuming (Ebersberger and Herstad, 2012; Gupta and Govindarajan, 2000; Hotho et al., 2011; Kasper et al., 2013; Wang and Zhou, 2013), and may thus slow down the innovation process and the development of new capabilities. High levels of network breadth may further make the meaningful combination of diverse ideas and technologies less efficient as business groups often face difficulties in managing complex knowledge systems (Ebersberger and Herstad, 2012; Hashai and Delios, 2012). In such cases, locating units in too many areas may have little economic value and may be detrimental for innovation, capabilities and performance.

The above discussion suggests that network breadth curvilinearly moderates the effects of technology transfer on business units' performance. These effects will take an inverted U-shape. Hence, lower or moderate levels of network breadth will have positive consequences for the performance of business units, whereas these effects will be negative at higher levels of breadth. Hence:

Hypothesis 1: The breadth of a *group's network of business units has a curvilinear* moderating effect (taking an inverted U-shape) on the relationship between *the group's* technological knowledge stock and its business unit*s'* operational performance.

3.2 Network Concentration

The benefits of intra-group technology transfer depend on the ability of various units to receive and integrate external knowledge in their own knowledge stocks and technologies and transfer useful knowledge and technologies to other units. As knowledge is not perfectly mobile in the geographical space, knowledge transfer requires proximity between the knowledge source and the recipient (Macher and Mowery, 2009; Nonaka, 1992; Szulanski, 1996). When network concentration is higher and the group has multiple units operating in the same city, the business units can increase interaction with other units and employees can meet each other, strengthening their ties (Hotho et al., 2011).

As some of these units serve similar markets, they need similar technologies and knowledge to facilitate the process of assimilating new knowledge with their existing knowledge base (Abecassis-Moedas and Mahmoud-Jouini, 2008; Cohen and Levinthal, 1990; Lo and Chung, 2010). Accordingly, economies of agglomeration enable units operating within the same area to also benefit from knowledge diffusion, similar suppliers and customer bases. Hence, higher relatedness of the sourced knowledge may accelerate knowledge absorption between units. Furthermore, there are group-wide benefits from increasing the number of units in one area (Coe and Lee, 2013). Hence, network concentration may facilitate the technology transfer process by increasing a unit's ability to access such knowledge.

Nevertheless, particularly high levels of network concentration come with a set of drawbacks that may have a negative impact on business unit performance. Communication theory emphasizes the importance of promoting knowledge transfer across business units by increasing their willingness to share their technological discoveries with other units of the same group (Hotho et al., 2011). Although network concentration increases the ability of the units to send and receive knowledge, their willingness to do so decreases. For example, extant research suggests that negative externalities arising from increased appropriability hamper innovators' willingness to establish collaborative ties (Ter Wal, 2013). Units that operate in the same city serve the same market and customers, and sharing knowledge may result in increased competition between the units. Similarly, as discussed earlier, intra-firm tension may also arise if units are linked but imperfectly integrated. This may result in certain units competing with each other, thus leading to decreased willingness to transfer knowledge. Hence, when network concentration is particularly high, a unit may increasingly protect its knowledge and attempt to monopolise certain knowledge. The unit may also try to maximize the benefits of possessing unique and valuable technologies, which may assist it in gaining more resources and bargaining power over other units within the group (Cyert, 1995; Pfeffer, 1981).

Moreover, because of the way agglomeration affects urban economies, units that operate in the same city are likely to possess similar knowledge and experience. This overlap increases the difficulty of identifying synergies and complementarities. In such situations, a higher network concentration level may hinder the role of the group's knowledge stock in enhancing individual business units' performance. Locating several units in cities in which the group already maintains operations may decrease the value that the organization derives from its network because some of these business units may become partially redundant (e.g., Lo and Chung, 2010). This view is in line with the premise that when organizations make competing investments, duplication may decrease the overall value of the network because a unit may erode the marginal contribution of fellow units that operate in the same market (Lai et al., 2010; Oxley and Sampson, 2004; Vassolo et al., 2004). In such situations, the value of collocation will decrease as the degree of network concentration increases.

In summary, network concentration impacts the ability and willingness of business units to transfer and receive knowledge and technologies (Figure 2). Although in principle business units are better able to transfer technology when network concentration is high, their ability to do so does not matter so much because their willingness to share their discoveries is particularly low due to intra-firm competition. It follows that network concentration curvilinearly moderates the effects of technology transfer on business unit operational performance, taking an inverted U-shape. Lower levels of network concentration will have positive performance effects, whereas these effects will be negative at higher concentration levels. Hence:

Hypothesis 2: The concentration of a *group's network of business units has a c*urvilinear moderating effect (taking an inverted U-shape) on the relationship between *the group's* technological knowledge stock and its business unit*s'* operational performance.

Insert Figure 2 here.

4. Methods

4.1 Sample and data

Prior research on innovation and firm performance centers on developed economies. Although a rapidly growing share of the world's total R&D investment (UNCTAD, 2005) is undertaken in emerging countries such as China and India, we know little about the role of technology transfer and how network structure influences firm performance in these countries. This is particularly important as intellectual property right (IPR) protection in emerging countries, such as China, is far from adequate (e.g., Fan, 2006; Wang and Zhou, 2013; Zhao, 2006). To address this limitation and test the conceptual framework, the analysis in this paper focuses on the largest emerging economy (China).

China witnesses a remarkable rate of economic and technological growth. Although the country was initially a source of cheap labor and a manufacturing workshop for developed countries, China now plays a crucial role in the technological battlefield (Zhao, 2006). More importantly, China is a country with a high degree of geographical diversity and dispersion

(Zhou et al., 2011), and therefore spatial configurations of networks vary significantly across firms, making it a suitable context for testing our hypotheses. Additionally, although China devotes an increasing amount of resources to R&D and encourages technology diffusion and knowledge transfer from abroad, an issue that remains unclear is whether Chinese firms succeed in employing their own internal knowledge to improve their performance. Therefore, the country provides an appropriate setting for examining the moderating effect of business groups' internal network configurations on units' operational performance.

To test the hypotheses, we analyse knowledge intensive business groups with R&D-active business units (i.e., units that both conduct R&D and generate sales). We use the Annual Report of Industrial Enterprise Statistics compiled by the National Bureau of Statistics of China (NBS). This database provides detailed financial and operational information for all state-owned enterprises and large non-state-owned enterprises with an annual turnover of over five million RMB. The database provides the most comprehensive statistics collected by the NBS, accounting for about 90% of the total output in most industries. As our analysis focuses on uni-national organizations, the sample includes Chinese locally-owned enterprises. From the sample, we identified 283 business units that belong to 68 groups. To do so, we collected information on whether an organization is the parent or a subsidiary unit and further identified the registration code of the related units.

We conducted additional checks about the groups by examining the names of the parent and subsidiary enterprises. To ensure that we examine R&D active units with comparable capabilities, the estimation excludes units that belong to groups that do not conduct R&D. The units of the sample operate in 31 provinces in China, providing sufficient spatial variation. These compete in 25 two-digit industries (NBS, 2006). This sample facilitates the investigation of units that belong to groups with sufficient technological scope. The data cover the 2003-2007 period, enabling the examination of fairly recent years during which

Chinese firms become increasingly active in R&D. The total number of observations is 1415. As we also control for region characteristics specific to the examined business unit, region-specific data were collected from China Statistical Yearbooks (NBS, 1999-2008), and Comprehensive Statistical Data and Material on 60 years of New China (NBS, 2010). These provide comprehensive sources of information about economic activities in China's provinces.

4.2 Measures

4.2.1 Dependent variable

We use regression analysis and a logarithmic model to assess the effects of business group configuration on unit performance. Although there are two main aspects of performance (namely, financial and operational), it has been established in the literature that a measure of operational performance that reflects a firm's productivity is more appropriate when studying the effects of innovation and technology (Adams and Jaffe, 1996; Kafouros and Buckley, 2008). The dependent variable of the model is Business Unit Operational Performance which refers to the ability of a business unit "to combine efficiently a number of resources to engage in productive activity and attain a certain objective" (Amit and Schoemaker, 1993; Dutta et al., 2005: 278). It is therefore seen as a measure of the "transformation ability" between inputs and outputs (Dutta et al., 2005). Following this reasoning, a unit's operational performance is the efficiency with which a unit uses a given set of resources (i.e., inputs including human and capital) available to it to achieve certain objectives (i.e., outputs such as sales). Building upon the work of Dutta et al. (2005), we operationalize the operational performance of each unit i in year t as:

$$A_{it}=Y_{it} / e^{\varepsilon it}K_{it}^{\alpha}L_{it}^{\beta} \qquad (1)$$

Where subscripts i and t indicate the unit and year under consideration. Y_{it} refers to the output created by the unit, as measured by sales. K_{it} and L_{it} denote the unit's capital and human resources, and are proxied by a unit's total net fixed assets (at 2002 constant price) and total number of employees, respectively; α and β are the coefficients of human and capital resources; and ε_{it} is the error term. Therefore, the term A_{it} (the unit's operational performance) captures differences in output that are not the result of variation in the level of human and capital inputs. This approach is well established in several literatures (Dutta et al., 2005).

4.2.2 Independent variables

Network Breadth of the Group: This variable captures the extent to which the network of business units of the group in which a unit belongs (the "corresponding group" thereafter) is spread across different geographical areas. To capture how widely the group spreads its units, we operationalize this variable using the number of cities in which the units of the corresponding group operates. Hence, the greater the number of cities in which the group operates, the higher the breadth of its network of units. This approach is consistent with measures employed by numerous other studies to capture the geographic scope of business activities (e.g., Allen and Pantzalis, 1996; Liang et al., 2013; Tang and Tikoo, 1999).

Network Concentration of the Group: Another key independent variable of the framework is the network concentration of the corresponding group. This construct captures the degree to which the network of units of a given group is concentrated within a certain geographical area. The economic geography literature underscores the role and evolution of cities (e.g., Frenken and Boschma, 2007) and the externalities residing within a given geographical area (e.g., Glückler, 2007; Kloosterman, 2008). Hence, the city is considered as an appropriate level of analysis. Following previous studies (Allen and Pantzalis, 1996; Tang and Tikoo, 1999), network concentration is operationalized by measuring the number of business units that the corresponding group has established in each given city. Thus, the higher the number of business units per city, the higher the concentration of the group. One of our concerns was that larger groups might have higher network concentration because they have a larger number of business units. To check whether group size is related to network concentration, we examined the correlation between our measure and group size (as measured by sales). We found the correlation to be sufficiently low, suggesting that the extent to which a business network is concentrated is not affected by group size.

Knowledge Stock of the Unit: Our analysis further captures each business unit's stock of scientific or technological knowledge. We operationalize this variable by employing the R&D spending of the unit (at 2002 constant price) and the commonly used perpetual inventory method (Griliches, 1979; Kafouros and Buckley, 2008). This measure relies on the idea that the R&D stock that resides within a unit depends on both current and past R&D expenses. We take into account the depreciation of old knowledge and technologies over time, and thus depreciate the cumulative R&D expenditures using a 15% rate per annum. This approach therefore recognizes that although past R&D plays an important role because it adds to the firm's knowledge base, its impact on performance is not as high as that of the ideas and technologies created more recently.

Knowledge Stock of the Group: Following the approach described above, we construct a measure of knowledge stock for each corresponding group using the sum of R&D stock of all other units of the same group. We deducted the focal unit's own R&D stock from the R&D stock of the entire group to control for double counting.

4.2.3 Control variables

Technological Differentiation of the Unit: As discussed earlier, fellow business units may compete with one another in situations where they operate in the same product market, by developing comparable products or investing in similar technologies (Birkinshaw and Lingblad, 2005). We thus need to capture the extent to which the technologies and products developed by a given business unit differ from the technologies and products created by other units of the same group. Building on prior research on the role of technological distance (or differentiation) between businesses (e.g., Kafouros and Buckley, 2008), we operationalize this variable using the ratio of the number of units operating in product segments different from that of the focal unit to the total number of business units within a given group. Hence, a higher ratio indicates a greater degree of differentiation for that unit (that is, only a few units operate in the product segment in which the focal unit operates).

Product Diversification of the Group: According to prior studies (Hashai and Delios, 2012; Hitt et al., 1997; Lai et al., 2010), product diversification may result in different innovation and performance outcomes, especially in organizations that have geographically distributed activities. To control for these effects, we develop a commonly used product diversification measure that relies on the number of key product segments in which the corresponding group competes.

Size of the Unit: Prior studies suggest that size may affect the performance and performance of a unit. The dependent variable takes into account the unit's human and capital resources, and is therefore normalized for size. Nevertheless, to ensure that the results are not affected by size, this study further uses a dummy variable that takes the value of 1 when the focal unit's annual sales are above the median sales of the sampled units.

Size of the Group: This variable controls for the size of the group. It relies on a dummy that takes the value of 1 when the annual sales of the corresponding group are above the median of the sales of the sampled groups. Importantly, this variable further controls for the possibility that larger groups may have both higher network breadth and higher concentration.

Regional Inward FDI Intensity: Inward FDI may influence economic growth in a given location and may lead to better technological opportunities and knowledge spillovers. However, inward FDI enters China's regions at different pace, resulting in different degrees of economic growth and liberalization, an important indicator of competition among economic entities at the regional level (Fu, 2008). We take inward FDI stock and normalize it for size by calculating a ratio of FDI stock to the output of the province in which the unit is located. FDI stock is computed using accumulated FDI flows at 2002 constant prices. FDI flows include mergers, acquisitions, and greenfield investments, hence, capturing the overall investments and operations of foreign MNEs in a region.

Regional Domestic Knowledge Stock: Huang et al. (2012) suggest that China's provinces are characterized by relatively independent innovation systems. Following studies of regional innovation (e.g., Acs et al., 2002) we control for regional-specific innovation efforts of firms by including a variable of the accumulated number of patents granted to domestic enterprises in the province where the unit is located.

Unit-level Time and Industry Effects: As idiosyncrasies associated with time and industry-specific effects can impact unit operational performance, the model includes a set of year and industry dummy variables to control for variations in terms of time and sectors.

5. Analysis and Results

Table 1 provides summary statistics for the key variables of the study. To detect potential multicollinearity, we calculate the variance inflation factor (VIF) for each variable. The average VIF across the models is considerably below the acceptable level of 10 (Neter et al., 1985), indicating no serious problems of multicollinearity. Following the usual practice (Aiken and West, 1991), we mean-centered the interaction variables to alleviate potential multicollinearity problems and allow better interpretation of the interaction terms (Aiken and West, 1991). The average VIF values of the interaction terms after mean-centering are also below the acceptable cut-off point of 10. Because we theorize that factors specific to business units explain variations in their performance and our examination includes two time-invariant variables (Size of the Unit and Size of the Group), we estimate the model using Panel Least Squares (PLS) with cross-sectional random effects. Following Certo and Semadeni (2006) we control for contemporaneous correlation and heteroskedasticity by producing robust estimators, calculating standard errors and covariances using the White cross-section method following Wooldridge (2002, p. 148-153) and Arellano (1987). Table 2 reports both the main regression results that test the two hypotheses and additional robustness tests (which are discussed in the next section).

Insert Table 1 here.

Insert Table 2 here.

Model 1 includes only the control variables and thus serves as the baseline model. To test whether a unit can increase its operational performance by drawing upon the knowledge and technologies created within the group, Model 2 incorporates a measure of the Knowledge Stock of the Group. The effect of this measure is positive and statistically significant ($p<0.001$). The results confirm the predictions of the theoretical framework, indicating that the internal knowledge of a business group has important consequences for the performance of its units. To test the hypotheses, we use moderated regression analysis (Aiken and West, 1991) and enter two-way interactions in Models 3-6 (Model 7 is the full model). As the capacity to absorb knowledge depends on the organization's own R&D efforts (Cohen and Levinthal, 1990; Tsai, 2001), in Model 3 we control for this effect by entering an interaction term between the Knowledge Stock of the Group and the Knowledge Stock of the Unit. This ensures that Hypotheses 1 and 2 are properly tested. This interaction term produces a positive effect on Business Unit Operational Performance, confirming the view that the knowledge generated within the group is more beneficial for R&D intensive units.

Model 4 incorporates two two-way interactions to test the moderating effects of network breadth and concentration. Model 5 further includes the interactions of the squared terms to test for the curvilinear form of the moderating effects of Network Breadth. Similarly in Model 6, interactions of the squared terms of Network Concentration were added. The first hypothesis involves the role of the Network Breadth of the Group. As Models 4, 5 and 7 indicate, the interaction term between the Knowledge Stock of the Group and the Network Breadth of the Group has a positive effect on business unit performance, while its squared term produces a negative effect. These results show that the moderating effect of network breadth is curvilinear (taking an inverted U-shape), thus fully supporting Hypothesis 1. The geographical dispersion of a group's activities enables its units to employ location bound knowledge resources that can be accessed by other units of the group. The individual units are thus able to overcome local search and exploit ideas in diverse locations and contexts. Nevertheless, while lower or moderate levels of network breadth are beneficial, the results suggest that particularly high levels of network breadth reduce a unit's ability to exploit the knowledge generated by its fellow units.

Turning to the second hypothesis, Models 4, 6, and 7 show that the interaction terms between the Knowledge Stock of the Group and the Network Concentration of the Group produce a negative effect on business unit operational performance. The squared term continues to have a negative sign and only significant at 10%, demonstrating that the moderating effect of network concentration is not curvilinear. These results provide only partial support to Hypothesis 2, showing that the performance-enhancing effects of the technologies and knowledge developed within the group by fellow units are lower when the corresponding group's network concentration is higher. These results suggest that a unit's performance is negatively influenced by the geographical concentration of units from the corresponding group as intra-firm competition increases. Technology transfer within the group becomes limited when units' willingness to collaborate and share knowledge declines. It seems that this effect is strong enough to offset the benefits arising from proximity and increased ability to transfer.

5.1 Additional analyses and robustness checks

We estimated a number of additional models to examine the robustness of our results. First, because the two variables controlling for region-specific characteristics (Regional FDI intensity, and Regional Domestic Knowledge Stock) are highly correlated (0.72), we tested whether they impact the overall results. Model (9), which excludes one of the variables, shows that the results for the hypotheses do not change. Second, we investigated whether intra-firm technology transfer depends on a number of other factors pertaining to the geographical configuration of the business group. To begin with, we examined the role of the focal unit's average geographical distance to its fellow units. To capture this distance for each unit separately, we first obtained the dyadic motorway distance for each pair of units, and then calculated the average distance between the focal unit and other fellow units. The results, which are reported in Model 9, indicate that the interaction term between the Knowledge Stock of The Group and Distance to Other Units of the Same Group is statistically insignificant. This result suggests that the distance between units alone does not play an important role in explaining the effects of intra-firm technology transfer. This result is justified by the fact that the uni-dimensional nature of measures that simply rely on distance fail to capture the different facets of a group's network.

Furthermore, our results support the view that network concentration decreases units' willingness to share knowledge as it intensifies the rivalry between units. However, one might argue that proximity might not have a negative effect on knowledge sharing between the units of a highly diversified group that consists of independent, and thus non-competing, business units. Although our analysis controls for the technological differentiation of the unit (i.e., the extent to which the technologies and products developed by the focal unit differ from those created by other units of the same group), we further interacted the technological differentiation variable with the terms involved in Hypothesis 2. As Models 10-13 indicate, this addition has not changed the results associated with Hypothesis 2.

Additionally, the new interaction, Knowledge Stock of the Group × Technological Differentiation of the Unit × Network Concentration of the Group (Models 10, 12 and 13), produced a positive sign ($p>0.001$), suggesting that the joint effects of network concentration and group knowledge on unit performance becomes positive when the unit is more differentiated from other units of the same group. In other words, the results echo our previous discussion regarding the role of agglomeration economies and shed light on the importance of the mandate of a specific unit. If the unit is differentiated from fellow units, it will benefit more from the group's investment concentrated in a cluster. The interaction for the curvilinear effects (Knowledge Stock of the Group × Technological Differentiation of the Unit x Network Concentration of the Group^2) in Models 12 and 13 did not produce any significant result, suggesting that Technological Differentiation of the Unit only has an influence on the linear moderating effect of network concentration.

We also conducted a similar analysis for network breadth. As Models 10, 11, and 13 show, this did not change the results associated with Hypothesis 1. Unlike the effect of concentration, the new interaction, Knowledge Stock of the Group × Technological Differentiation of the Unit × Network Breadth of the Group (Models 10, 11 and 13), produced a negative sign ($p>0.001$). This suggests that the unit performance is higher when both network breadth and group knowledge increases but the unit is less differentiated from other units of the same group. In other words, this reflects that business groups can tap into a wider range of knowledge sources through increasing network breadth but the benefits will be reduced if the unit differs so much from its fellow units that the diverse sources accessed by the group are not relevant anymore. Similar to the former analysis, the curvilinear effects (Knowledge Stock of the Group × Technological Differentiation of the Unit x Network Breadth of the Group^2) in Models 11 and 13 did not produce any significant result, suggesting that Technological Differentiation of the Unit only has an influence on the linear moderating effect of network breadth.

6. Discussion and Conclusion

In this study, we examine how the location strategy of business groups in a large emerging country (China) influences the effects that intra-firm technology transfer has on business unit performance. Although the effects of characteristics such as absorptive capacity in influencing knowledge transfer is well established in the literature (Tsai, 2001), prior research has not focused on how location choices – a fundamental component of strategy and innovation – influence knowledge transfer and therefore performance. Our findings extend current thinking on technology transfer by revealing that the variations in business unit performance are driven by the idiosyncratic manner in which the group configures its network of units. Because some fellow units invest in comparable products and technologies (Birkinshaw and Lingblad, 2005), they often compete with one another. Locational variations in network breadth and concentration change the intra-group dynamics for collaboration and competition, influence the ability and willingness of units to transfer knowledge and, subsequently, their performance.

Prior research on knowledge transfer implicitly assumes that all firms have similar network structures. This omission is important because it overlooks that the technology developed within the group may not be equally beneficial to all units. We overcome this limitation by incorporating the group's entire network of units, thus capturing how such units both independently and collectively impact performance. Our findings imply that even when two groups have a similar number of units, they may differ in terms of network breadth and concentration, which in turn can lead to different performance outcomes. This finding contributes to the international business and geography literature by showing that merely participating in clusters or achieving proximal access to a particular location is not sufficient for improving firm performance. One implication here is that the way in which the firm distributes its other units relative to the unit in question determines whether this unit can benefit from being located in a certain geographical area and, ultimately, whether the whole group can benefit from (geographically) structuring its units in a given way. As our study therefore documents how firm-specific advantages originate from locational variations, it may help managers evaluate the strategic implications of their location choices.

Our analysis extends prior research on international business in emerging countries by demonstrating that the differential effects of technology transfer can be explained by differences in the geographical distribution of business units. This view underscores the importance of thinking in careful ways about how business groups are structured and how variations in the configuration of such networks lead to performance differences. It also captures complementarities and synergies within the business group, and therefore deepens understanding of how group- and unit-specific factors jointly shape business unit performance. The way in which a group configures its network of business units may lead to a specific set of both benefits and costs, which according to the results, vary considerably depending on the group's network breadth and network concentration.

Through intentional technology transfer and unintentional knowledge spillovers, a business unit can benefit from the technologies developed within the group. Yet, these positive consequences are co-founded with negative effects associated with intra-firm competition, which may arise either from the intention of the HQ to create strategic options (Kalnins, 2004) or when units compete in similar markets and technological domains (Birkinshaw and Lingblad, 2005). Despite these negative consequences, the findings indicate that the net effect of intra-firm technology transfer on business unit operational performance is positive, highlighting the strategic role and the implications of internal knowledge diffusion for firm performance (e.g., Ebersberger and Herstad, 2012; Hotho et al., 2011; Lai et al., 2010; Macher and Mowery, 2009; Tsai and Ghoshal, 1998; Tsai, 2001; Wang and Zhou, 2013).

The findings enrich understanding of the technological forces shaping the performance of emerging market firms, which typically do not possess strong technological capabilities. Our findings indicate that emerging market organizations can successfully improve their operational performance by transferring technologies across business units, but the effectiveness of such practices largely depends on the network configuration of a given business group. A theoretical implication is that group-level decisions pertaining to the location of business units have significant power in explaining why some groups succeed in benefiting from intra-firm technology transfer while others fail to do so. By demonstrating that the performance-enhancing effects of technology transfer are contingent upon the location of the unit in relation to that of fellow units, the analysis complements research on absorptive capacity that emphasizes the role of the unit's innovation efforts (Hotho et al., 2011; Tsai, 2001).

Our findings also contribute to research on business groups and multi-unit organizations (e.g., Birkinshaw and Lingblad, 2005; Hashai and Delios, 2012; Hotho et al., 2011; Lai et al., 2010) by specifying the consequences of two important location strategies. First, operating in too many locations increases complexity, makes the combination of diverse ideas and technologies less efficient, and can be detrimental for innovation and capability development. As the empirical findings confirm, network breadth has a curvilinear (inverted U-shape) moderating effect. To enhance business unit operational performance, and therefore the performance of the entire group, business groups should adopt a network configuration that has sufficient, but not excessively high, breadth. Decentralizing a firm's R&D activities enables the firm to tap into technological resources resident in different cities and accumulate knowledge from diverse locations (Florida et al., 2012; Lai et al., 2010; Leiponen and Helfat, 2010). When network breadth is excessively high, its benefits are not sustainable since the group's network is too dispersed and physical distance between units inhibits technology transfer (Gupta and Govindarajan, 2000; Hotho et al., 2011).

Second, the negative consequences of intra-firm competition can be avoided by maintaining network concentration at lower levels. Although the ability to transfer knowledge to, or receive knowledge from, fellow units improves as network concentration increases, the willingness to do so decreases significantly (Lai et al., 2010; Lo and Chung, 2010; Oxley and Sampson, 2004; Vassolo et al., 2004). The managerial implications of the finding of a negative linear rather than an inverted U-shaped curvilinear effect of network concentration are as follows. Business groups with higher levels of network concentration should introduce management practices that will strongly encourage their units to share technologies with one another (e.g., Bertels et al., 2011). Equally, multi-unit businesses can enhance the benefits of intra-group technology transfer by specific configuration of the breadth of their networks of units. Overall, this study indicates that the degree to which a firm benefits from knowledge transfer depends on the breadth and concentration of its network of units; and therefore it is important for firms to consider the trade-off between the two geographic dimensions in their strategic plans.

Finally, our findings help to bridge two research streams in economic geography literature; namely, studies on global innovation and research on clustering and agglomeration. Prior research has developed valuable explanations of the processes and outcomes of innovation activities configured within MNEs across different countries. However, with the exception of a few studies (e.g., Coe and Lee, 2013; Ebersberger and Herstad, 2012; Wood and Reynolds, 2012), it has not fully addressed the question of whether similar mechanisms and principles apply at more disaggregate levels, i.e., among cities within one country. Our findings of the intrinsic effects that arise from variations of firms' internal networks show that differences in a firm's internal spatial concentration and dispersion at city level can generate complex and varied performance outcomes. This strengthens our understanding of the profound importance of innovation to fuel the evolutionary momentum of regions of a country (e.g., Wang and Lin, 2013; Zhou et al., 2011). Our findings show that because many firms are in fact units of a business group, explanations of the co-location phenomenon (its drivers, benefits, and costs for participating businesses) should take into account internal technology transfer and knowledge diffusion processes. Without using appropriate controls for these, what appears to be influences from the "environment" driving collocation may actually be endogenous forces. Hence, this approach extends understanding of how externalities arising from clusters are absorbed through the internalization efforts of local business groups.

Nevertheless, the findings should be interpreted in the light of a number of limitations, some of which offer opportunities for future research. One limitation concerns the generalizability of the results. Our study examines knowledge transfer in groups that conduct R&D and have several business units, but our results do not apply to particularly small and non-innovative firms. In addition, we focus on China, which is a particularly large and diversified economy compared to other emerging economies. Although this setting may limit the generalizability of the results, the fact that cities and regions in China show a high degree of heterogeneity makes China an appropriate setting for testing our hypotheses. Future research may extend the current study by testing this theoretical framework in other countries either emerging or developed. This examination will establish whether the implications of breadth and concentration are similar or not in other settings and contexts. Second, our focus on uni-national firms enables us to examine variations at the city level. Although we capture such differences within one country, future studies can replicate our approach by using data for business groups that operate in several countries.

Third, the theoretical framework discusses the role that intra-firm competition, willingness and ability to transfer knowledge. Yet, we do not empirically capture these constructs. To extend theory about the implications of technology transfer, future analyses should examine the complexity of intra-firm competition and the relationships between business units. These dynamics may manifest themselves in various forms and may therefore moderate the effects of network concentration and breadth on business unit operational performance. This extension would greatly enhance understanding not only of which knowledge transfer strategies are more valuable, but also of how business units interact to shape the competitiveness and capabilities of a group.

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Figures and Tables

Figure 1 – Conceptual Framework

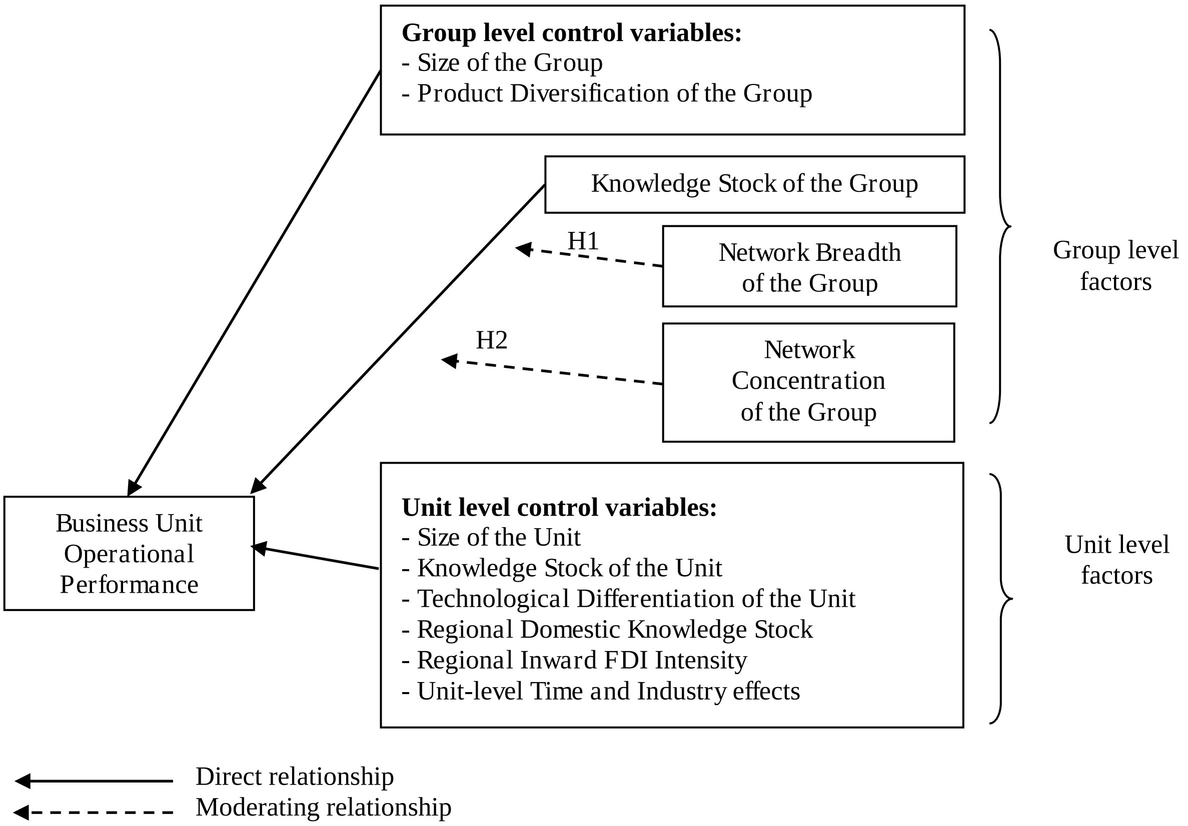

Figure 2 – Effects of network concentration on the ability and willingness to transfer technology.

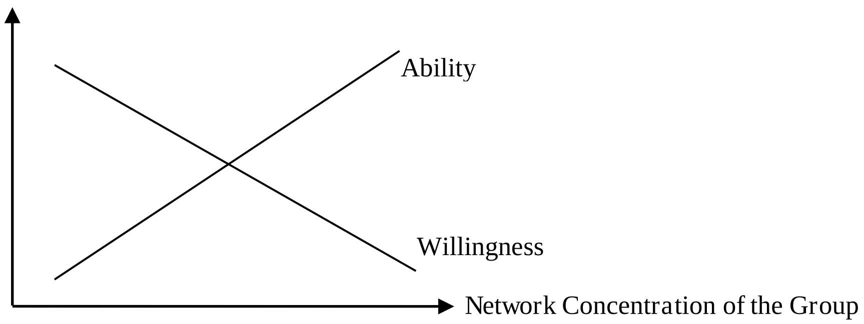

Table 1 Descriptive statistics and correlation matrix

		Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Knowledge Stock of the Unit	54608.21	179258.40														
2	Knowledge Stock of the Group	361323.30	592966.50	0.30													
3	Size of the Unit#	0.49	0.50	0.37	0.12												
4	Size of the Group#	0.66	0.47	0.27	0.57	0.29											
5	Technological Differentiation of the Unit	0.54	0.33	-0.24	-0.36	-0.07	-0.32										
6	Product Diversification of the Group#	2.32	1.70	-0.13	0.07	-0.06	0.22	0.48									
7	Regional Domestic Knowledge Stock	21103.36	26174.02	0.08	-0.03	-0.07	-0.24	-0.02	-0.07								
8	Regional Inward FDI Intensity	0.23	0.20	-0.07	-0.15	-0.16	-0.29	0.10	-0.02	0.72							
9	Network Breadth of the Group	4.22	3.61	0.08	0.44	0.26	0.52	-0.22	0.44	-0.16	-0.24						
10	Network Concentration of the Group	0.59	0.25	-0.02	-0.08	0.23	0.01	0.23	0.13	-0.13	-0.15	0.52					
11	Distance to Other Units of the Same Group	913.80	843.20	0.00	0.23	0.17	0.25	-0.16	0.21	-0.14	-0.25	0.55	0.28				
12	Business Unit Operational Performance	1.56	1.76	0.27	0.13	0.54	0.17	-0.03	-0.09	0.14	0.08	0.14	0.09	0.07			
13	Sales of the Unit	2960290.00	6490236.00	0.44	0.23	0.79	0.36	-0.08	-0.02	-0.01	-0.11	0.33	0.18	0.20	0.74		
14	Capital of the Unit	843621.20	1860715.00	0.37	0.23	0.68	0.36	-0.07	0.05	-0.08	-0.17	0.37	0.15	0.25	0.30	0.83	
15	Total Number of Employees in a Unit	3787.53	6696.77	0.41	0.19	0.62	0.36	-0.10	0.04	-0.18	-0.26	0.33	0.21	0.21	0.10	0.71	0.81

Note: Pearson Correlations (two-tailed); figures in bode if p<0.01. The number of observations is 1415. Mean and standard deviation are statistics for variables in original form (i.e., without logarithmic transformation). All variables have entered the estimation equation with a logarithmic transformation, except those with the superscript #.

Table 2 Regression results (dependent variable: Business Unit Operational Performance)

	Main models							Robustness tests					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Knowledge Stock of the Unit	0.013 (2.91)**	0.010 (2.59**)	0.017 (4.22)***	0.016 (4.91)***	0.017 (5.12)***	0.017 (5.45)***	0.018 (5.63)***	0.018 (5.64)***	0.017 (4.54)***	0.018 (5.33)***	0.018 (5.19)***	0.019 (6.20)***	0.019 (6.12)***
Knowledge Stock of the Group		0.012 (7.05)***	0.023 (5.31)***	0.066 (3.89)***	0.069 (5.20)***	0.038 (3.10)**	0.042 (4.39)***	0.041 (3.92)***	0.022 (11.30)***	0.109 (4.18)***	0.118 (5.11)***	0.076 (2.70)**	0.086 (3.26)***
Knowledge Stock of the Group × Knowledge Stock of the Unit			0.002 (4.37)***	0.001 (2.91)**	0.002 (2.92)**	0.001 (2.50)*	0.001 (2.56)*	0.001 (2.64)**	0.002 (5.04)***	0.002 (2.09)*	0.002 (2.04)*	0.002 (2.24)*	0.002 (2.21)*
H1: Knowledge Stock of the Group × Network Breadth of the Group				0.047 (2.57)*	0.045 (2.93)**	0.041 (2.14)*	0.043 (3.42)***	0.043 (3.33)***		0.094 (3.03)**	0.097 (3.14)**	0.090 (2.70)**	0.099 (3.25)**
H1: Knowledge Stock of the Group × Network Breadth of the Group^2					-0.033 -(2.62)**		-0.039 -(2.56)*	-0.038 -(2.59)**			-0.049 -(4.05)***		-0.077 -(2.87)**
H2: Knowledge Stock of the Group × Network Concentration of the Group				-0.061 -(2.15)*	-0.101 -(3.06)**	-0.022 -(2.30)*	-0.066 -(3.29)***	-0.064 -(3.65)***		-0.115 -(3.92)***	-0.168 -(6.00)***	-0.074 -(3.02)**	-0.153 -(3.53)***
H2: Knowledge Stock of the Group × Network Concentration of the Group^2						-0.083 -(1.93) †	-0.096 -(1.95) †	-0.098 -(1.96)*				-0.110 -(2.48)*	-0.155 -(2.49)*
Knowledge Stock of the Group × Distance to Other Units of the Same Group									0.000 -(0.15)				
Knowledge Stock of the Group × Technological Differentiation of the Unit × Network Breadth of the Group										-0.102 -(4.01)***	-0.108 -(3.11)**	-0.103 -(3.89)***	-0.111 -(3.30)***
Knowledge Stock of the Group × Technological Differentiation of the Unit × Network Breadth of the Group^2											0.019 (0.83)		0.052 (1.52)
Knowledge Stock of the Group × Technological Differentiation of the Unit × Network Concentration of the Group										0.098 (5.71)***	0.111 (2.94)**	0.107 (5.16)***	0.153 (3.51)***
Knowledge Stock of the Group × Technological Differentiation of the Unit × Network												0.018 (0.44)	0.065 (1.12)

Concentration of the Group2													
Size of the Unit	0.916 (9.57)***	0.928 (10.05)***	0.913 (9.97)***	0.892 (12.04)***	0.901 (12.14)***	0.844 (12.11)***	0.853 (12.08)***	0.852 (12.41)***	0.908 (9.89)***	0.916 (15.36)***	0.930 (15.28)***	0.856 (18.04)***	0.874 (17.63)***
Size of the Group	0.230 (1.68) †	0.190 (1.54)	0.163 (1.18)	0.063 (0.38)	0.036 (0.22)	0.013 (0.07)	-0.025 -(0.14)	-0.019 -(0.11)	0.164 (1.24)	0.020 (0.13)	-0.022 -(0.14)	0.024 (0.17)	-0.026 -(0.19)
Technological Differentiation of the Unit	0.150 (4.52)***	0.153 (4.78)***	0.162 (4.78)***	0.217 (2.76)**	0.243 (3.02)**	0.199 (2.84)**	0.227 (3.54)***	-0.096 -(1.77) †	0.168 (4.50)***	0.209 (1.95) †	0.187 (1.31)	0.230 (2.37)***	0.289 (2.01)*
Product Diversification of the Group	-0.059 -(2.88)**	-0.061 -(3.17)**	-0.062 -(3.17)**	-0.083 -(1.33)	-0.095 -(1.51)	-0.086 -(1.45)	-0.096 -(1.78) †	0.228 (3.50)***	-0.066 -(3.14)**	-0.089 -(1.37)	-0.103 -(1.56)	-0.106 -(1.51)	-0.117 -(1.75) †
Regional Domestic Knowledge Stock	-0.008 -(0.33)	-0.014 -(0.64)	-0.005 -(0.23)	-0.013 -(0.51)	-0.020 -(0.77)	-0.006 -(0.22)	-0.014 -(0.54)		-0.006 -(0.25)	-0.007 -(0.33)	-0.016 -(0.78)	-0.011 -(0.36)	-0.020 -(0.69)
Regional Inward FDI intensity	0.145 (2.98)**	0.149 (3.00)**	0.140 (2.77)**	0.153 (3.75)***	0.160 (3.66)***	0.108 (2.15)*	0.117 (2.35)*	0.108 (1.80) †	0.144 (2.83)**	0.155 (3.74)***	0.162 (3.71)***	0.120 (2.45)*	0.130 (2.59)**
Network Breadth of the Group				0.067 (0.48)	0.116 (0.88)	0.084 (0.58)	0.154 (1.31)	0.152 (1.32)		-0.049 -(0.29)	0.006 (0.04)	-0.024 -(0.13)	0.031 (0.19)
Network Breadth of the Group^2					0.026 (0.33)		-0.043 -(0.64)	-0.042 -(0.61)			0.012 (0.12)		-0.007 -(0.08)
Network Concentration of the Group				-0.084 -(1.59)	-0.083 -(2.21)*	-0.394 -(2.68)**	-0.453 -(4.65)***	-0.449 -(4.79)***		-0.022 -(0.38)	-0.022 -(1.30)	-0.332 -(2.01)*	-0.315 -(2.14)*
Network Concentration of the Group^2						-0.268 -(2.43)*	-0.280 -(2.97)**	-0.277 -(3.04)**				-0.356 -(2.56)*	-0.322 -(2.52)*
Distance to Other Units of the Same Group									0.005 (1.12)				
Technological Differentiation of the Unit × Network Breadth of the Group										0.266 (3.17)**	0.270 (3.02)**	0.258 (2.83)**	0.290 (2.87)**
Technological Differentiation of the Unit × Network Breadth of the Group^2											0.077 (0.62)		0.018 (0.12)
Technological Differentiation of the Unit × Network Concentration of the Group										-0.195 -(2.21)*	-0.090 -(3.37)***	-0.052 -(0.21)	-0.166 -(0.46)
Technological Differentiation of the Unit × Network Concentration of the Group^2												-0.088 -(0.62)	-0.181 -(0.99)
Knowledge Stock of the Group × Technological Differentiation of the Unit										-0.080 -(3.36)***	-0.188 -(1.45)	-0.074 -(2.45)*	-0.082 -(2.56)*

Constant	0.133 (0.41)	0.118 (0.42)	-0.138 -(0.50)	-0.534 -(1.07)	-0.523 -(1.21)	-0.447 -(0.88)	-0.433 -(1.04)	-0.578 -(2.79)	-0.130 -(0.47)	-0.920 -(1.62)	-1.023 -(1.85) †	-0.638 -(0.97)	-0.666 -(1.05)
Industry effects	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Time effects	included	included	included	included	included	included	included	included	included	included	included	included	included
Adjusted R^2	0.273	0.274	0.277	0.283	0.284	0.290	0.292	0.293	0.277	0.294	0.295	0.303	0.306
F-statistic	34.152	32.452	31.152	26.365	24.405	25.053	23.480	24.453	28.027	22.839	20.114	20.860	18.818

Notes: N=1415; Note: † if p<0.10, * if p<0.05; ** if p<0.01; *** if p<0.001. Figures in parentheses are t-statistics.