A network perspective on inter-organizational transfer of R&D capabilities: A study of international joint ventures in Chinese automotive industry

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ABSTRACT

The purpose of this study is to understand the transfer of R&D capabilities between organizations embedded in drastically different organizational contexts. We use a network perspective to study the transfer of R&D capabilities by multinational enterprises to their international joint ventures in the less developed countries. We identified different networks involved in the R&D capability transfer process from the perspectives of source organization, recipient organization, and the interface between them. We then assessed the impact of different attributes of these networks on the effectiveness of R&D capability transfer, based on the notion that R&D capabilities are largely collective knowledge. We provide suggestive empirical evidence from a qualitative study of the international joint ventures in the Chinese auto sector.

Key Words: R&D capabilities, networks, international knowledge transfer, joint ventures, collective knowledge.

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1. Introduction

Firms’ ability to develop R&D capabilities has been deemed critical in determining their survival and success (Schumpeter 1934; Selznick 1957; Nelson and Winter 1982; Prahalad and Hamel 1990). R&D capabilities are the capabilities of a firm that enable knowledge generation, recombination and integration to create new products and processes. In order to succeed in changing markets, firms typically must acquire R&D capabilities from other firms as well as develop R&D capabilities internally. Transferring R&D capabilities across firms requires substantial transfer and cultivation of tacit and organizationally embedded routines of integrating knowledge and skills to generate value, a process that is often complex and difficult.

The need to transfer R&D capabilities is not only realized by firms in the industrialized countries but also emphasized by firms in the less developed countries (LDCs) (e.g., Baranson 1977). The governments of many LDCs have issued policies to solicit not only the greater local production content but also greater local knowledge content of the multinational enterprises (MNEs) production in their countries. In recent years, under increased pressure from the local governments and the more globalized and intensified competition in their host countries’ markets, many MNEs have started to transfer R&D capabilities to their business partners in the LDCs. Facing this emerging phenomenon, we are intrigued by the issue of how firms transfer tacit and organizationally-embedded R&D capabilities effectively across country and firm boundaries. This study intends to bring more understandings to this question from both theoretical and empirical standpoints.

The theoretical tools used in the knowledge transfer literatures traditionally come from two camps. The first camp is led by transaction costs economics (TCE) (Williamson 1981; Teece 1986; Hennart 1988) and the internalization school (Hymer 1976; Dunning 1988), which emphasizes the behavioral assumption of opportunism and deals with the motivation, incentive mechanisms, and safeguard mechanisms involved in knowledge transfer. The second set of theoretical tools includes the resource/knowledge-based view and evolutionary theories (Nelson and Winter 1982; Fiol and Lyles 1985; Levitt and March 1988; Cohen and Levinthal 1990; Kogut and Zander 1992; Kogut and Zander 1993; Grant and Baden-Fuller 1995; Spender 1996; Argote and Ingram 2000). This camp emphasizes organizational cognitive abilities and activities more than the opportunism assumption. The main concern of this camp is to understand the processes of knowledge generation and coordination that occur within and across organizations.
Recently, network theory (Tichy et al. 1979; Granovetter 1985; Burt 1992; Powell, Koput and Smith-Doerr 1996; Ahuja 1996; Uzzi 1997; Gulati 1998) has started to join forces with the two traditional camps to explore the nature and dynamics of the knowledge creation, coordination and transfer among network members. With the tools of the network theory, we can gain better understanding of the storage and movement of knowledge among multiple agents from a more integral perspective.

The key contribution of this paper lies in its extension of the prior studies of knowledge transfer through adopting both the network and knowledge-based lenses to understand how a source organization’s teaching capability, a recipient organization’s learning capability, and the interface structure between them influence the success or failure of R&D capability transfer. We study two key network factors: network knowledge stock and network structure. We identify three networks involved in the IJV inter-partner R&D capability transfer: the source organization’s business network, the recipient organization’s business network, and the network connecting the source and recipient, which we refer to as the “bridge network”. The paper adopts a multilevel application network perspective. The first two networks arise at the inter-organizational level, whereas the third network functions at the level of the individual. The paper develops three sets of propositions, predicting the effects of the attributes of these three networks on the effectiveness of R&D capability transfer. In order to conduct a focused study on the coordination aspects of knowledge transfer mechanisms, the paper does not explicitly explore protection and motivation aspects of knowledge transfer.

We selected the activities of transferring R&D capabilities to the Chinese automotive industry as the empirical setting for this study for two reasons. First, there is growing evidence of MNEs transferring R&D capability to their joint ventures in this industry. Second, there are significant technological, cultural and managerial barriers between the source organization and the recipient organization in every IJV within this industry. These factors provide a natural setting to examine the interaction between two previously isolated networks, namely the networks of both foreign and local partner of a IJV, and understand how firms apply their network knowledge stock and design their inter-partner network structure to overcome the transfer difficulties and achieve effective R&D capability transfer.

We explore the predictions with a qualitative study involving interviews, field observations, and archival data. The interviews, in both Chinese and English, included fourteen
respondents from four international joint ventures in the Chinese auto sector, plus four officials from Chinese government agencies that are in charge of automotive industry and technology management. We undertook field observations at the R&D centres and manufacturing facilities of the four IJVs. The qualitative study provides substantial consistency for the predictions, plus a few intriguing surprises.

This paper proceeds as follows: (1) a theoretical review of key concepts about organizational knowledge and capabilities, especially R&D capabilities; (2) theoretically derived propositions of mechanisms that enable the effective transfer of R&D capabilities from both the resource-based and network perspectives; (3) research methodology and the scope of the fieldwork; and (4) initial empirical evidence collected from field observations and interviews related of MNEs’ transferring of R&D capabilities in the Chinese auto industry.

2. Organizational knowledge and R&D capabilities

In order to discuss the requirements and mechanisms for transferring organizational capabilities, we must first understand the meaning and characteristic dimensions of organizational capabilities. We consider conceptual relationships between organizational capabilities, organizational knowledge, and organizational routines.

First, let us consider the relationship between organizational knowledge and organizational capabilities. Many theorists have agreed on a taxonomy scheme of knowledge based on two general dimensions: (1) embeddedness and (2) tacitness (Kogut and Zander 1992; Nonaka and Takeuchi 1995; Spender 1996). Based on these two dimensions, Spender (1996) proposed a two-by-two array of knowledge taxonomy, within which conscious knowledge refers to the explicit individual knowledge, such as codified personal skills; automatic knowledge is the tacit individual knowledge, such as intuition and tacit experiences; objectified knowledge refers to the explicit embedded knowledge, such as codified organizing principles and procedures involving multiple agents or functional groups; and collective knowledge is the tacit embedded knowledge, such as shared code or coding scheme. The notion of collective knowledge also arises in related literatures, as a group or organization’s collective memory or collective interpretive scheme (Fiol and Lyles 1985; Levitt and March 1988), uncodified routines and organizing principles of social relations ( Nelson and Winter 1982; Kogut and Zander 1992), architectural knowledge and competences (Henderson and Clark 1990; Henderson and Cockburn 1994), and routines of interactions among member, tool and tasks (Argote and Ingram 2000).
Among these four types of knowledge, *collective knowledge* is considered as “the most secure and strategically significant kind of organizational knowledge” and the source for competitive advantage or long streams of high value-added “Penrose rent” (Spender 1996). Thus, collective knowledge becomes a key asset of the firm that can resolve the paradox between desired transfer and unwanted imitation (Kogut and Zander 1992; Argote, 2000) and, therefore, the key component of organizational capabilities or core competencies (Kogut and Zander 1992: 384; Prahalad and Hamel 1990). Therefore, organizational capabilities consist largely of organizational collective knowledge.

To understand the content of organizational capabilities, one also needs to address the relationship between organizational routines and capabilities. Nelson and Winter (1982) describe organizational routines as “organizational skill” or “what [the organization] knows”. Such skills provide systems of coordinating relations among the people and tasks in order to achieve productive performance. We can consider routines as small-scaled organizational collective knowledge, whereas organizational capabilities are the combination of routines of various levels and functions.

R&D capabilities can be defined as the capabilities of a company as a whole to create new knowledge, disseminate it throughout the organization, and embody it in products, services, and systems. Compared to manufacturing capabilities, R&D capabilities tend to have greater collective knowledge content (Nonaka and Takeuchi, 1994). The knowledge content arises for three reasons. First, R&D activities are performed when knowledge recombination is less finalized and not yet fully embedded into products, organizational structures, procedures and documents, or high in unprovenness and uncertainty (Pavitt 1990; Szulanski 1996). Therefore, the coordination among different knowledge carriers is more tacit and requires greater experience and on-the-spot discretion. Second, R&D activities require systemic collaboration among more functional departments (Pavitt 1990). Third, R&D activities span across multiple stages in the product development cycle.

Furthermore, R&D capabilities vary in the level of tacitness and embeddedness depending on (1) the level of complexity and maturity of the knowledge set embedded in the products or processes, which are the outcome of the R&D activities, and (2) the stage of R&D activities (Buckley and Casson 1976). The more complex the product or process and the earlier the R&D stages, the more extensive the division of labor in R&D activities, the more coordination that must
be undertaken among different knowledge holders, and the more difficult the recombination of their knowledge. For example, the R&D activities carried out by the General Motors technical center in the U.S. involves more early-stage components and requires larger asset investment and managerial coordination, comparing to GM’s R&D branches in other countries. The centers outside the U.S. mostly perform late-stage R&D activities and, therefore, have smaller size and lower coordination capacity.

In summary, the two key dimensions of capabilities are tacitness and embeddedness. Organizational capabilities are a kind of organizational knowledge that is mostly tacit and embedded among functional units and group of knowing entities. Organizational capabilities reside in the organizing principles governing interactions of various knowledge carriers, and involve norms, beliefs, routines, codes and coding schemes among organizational members. R&D capabilities tend to be among the most tacit and embedded of the capabilities of the firm.

3. Transfer of R&D capabilities

Although there exists a large body of literature on domestic and international technology transfer (Reddy and Zhao 1990), few studies have focused into the specific issue of transferring capabilities in the context of collective knowledge. With the understanding of the content and attributes of the collective knowledge involved in firms’ R&D activities, we can translate the issue of capability transfer into that of the transfer of collective knowledge.

When a capability has greater degree of tacitness and embeddedness, there are two consequences. A positive consequence is that this capability is more valuable in securing competitive advantage because it is less imitable than explicit and individual-carried knowledge (Penrose 1959; Dierickx and Cool 1989; Amit and Schoemaker 1993). A negative consequence is that it is more difficult to transfer this capability to other operations of the firm than explicit or individual-embodied knowledge.

MNEs’ R&D activities in the LDCs are mostly performed at the late stage of the R&D cycle, with the tasks such as debugging and adaptation of the general design to the local environment (Buckley and Casson 1976). In this paper, we will focus on MNEs’ transfer of late-stage R&D capabilities to their partners in the Chinese automotive industry.

3.1. The dynamic process of R&D capability transfer

The mechanisms for knowledge transfer can be categorized in two general types (1) discrete movement of knowledge from one site to the other and (2) modification of the recipient’s
knowledge stock through continuous interactions between the recipient and the source (Argote and Ingram 2000). To discretely move capabilities with high collective knowledge content requires the movement of an entire knowledge group, which involves physically moving a majority, if not all, of human members, equipments/tools, and functional jobs abroad to the recipient site. In business practices, this type of capability transfer happens when the recipient organization acquires or merges with the source organization. In the context of international technology transfer through international joint ventures (IJVs), firms rarely use the mechanism of transferring an entire knowledge group. Instead, capability transfer via IJV usually adopts the second mechanism, which is to modify the recipient organization’s existing routines through inter-partner teaching and learning.

Two levels of knowledge actions are involved in the process of transferring R&D capabilities through modifying the knowledge stock of the recipient. The first level of knowledge transfer involves transferring conscious, automatic and objectified knowledge, such as equipment-embodied knowledge (e.g., analytical and design equipments), document-embodied knowledge (e.g., blueprints, patents and testing procedures), and transferring human-embodied skills (e.g., design skills, analytical skills and testing skills). At this level, the recipient’s existing routines are not seriously challenged and changed by the new knowledge (Argyris and Schon 1978; Fiol and Lyles 1985; Nonaka and Takeuchi 1995).

The second level of knowledge transfer, on the other hand, refers to the transfer of collective knowledge components. In the process of the second level of knowledge transfer, the recipient’s existing routines will be challenged, modified or even eliminated, and the recipient must develop newer routines to effectively coordinate and recombine the acquired knowledge through the first level of transfer and generate new knowledge (Argyris and Schon 1978; Fiol and Lyles 1985; Nonaka and Takeuchi 1995). The second level of transfer, due to its involvement with

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2 In a similar categorical scheme, Baum and Ingram (1998) proposed three routine transfer mechanisms: (1) hiring routine-carrying employees from other organizations, (2) learning through personal contact and formal relationships, and (3) mimetic learning or vicarious learning through methods such as benchmarking and reverse engineering. Miner and Haunschild (1995) suggested the last two mechanism.

3 Many learning/knowledge-based theorists (Miner and Haunschild 1995, Huber 1991, Levitt and March 1988) have argued that knowledge can be copied or imitated without direct contact, through vicarious learning or mimicking. Level I routine transfer corresponds to this type of activities, which tend to be superficial and rely on codified and observable forms or knowledge carriers, and cannot deliver collective knowledge and belief systems.
more tacit and organizational-embedded knowledge, is much harder and more time-consuming (Dierickx and Cool 1989; Teece 1986). The focus of the following discussion is the second level transfer of R&D capabilities through the mechanisms of continuous interaction between the source and the recipient organizations.

3.2. Requirements for effective transfer of capabilities

Based on the understanding that the key attributes of R&D capabilities are tacitness and embeddedness, we can systematically identify the requirements for effective transfer of capabilities.

Requirements based on the tacitness of capabilities

To transfer tacit knowledge, three requirements must be met during the transfer process. First, intimate personal contact between the transferor and the transferee must be guaranteed. Transferring tacit knowledge can be done through direct interaction, first-hand observation, exposure to the source entity’s working environment, and socialization processes (Polanyi 1962; Nonaka and Takeuchi 1995). Second, learning of tacit knowledge can be carried out by doing. Nelson and Winter pointed out that organizations must “remember by doing” in order to acquire the tacit aspect of knowledge (1982: 99). Levitt and March (1988) echoed this point by noting that capability formulation is a process of collective memory accumulation through practices of tasks. Third, long-term commitment of collaboration by both sides of the transfer must be secured in order to transfer tacit knowledge, since the cumulative nature of the transfer of tacit knowledge engenders time compression diseconomies (Dierickx and Cool 1989), and thus calls for long-term and stable relationships between the source and recipient organizations (Nelson and Winter 1982; Teece 1986).

Requirements based on the embeddedness of capabilities

Embedded knowledge of a particular routine dwells in the interrelationships among a group of people. Therefore, the indivisible entity that understands the embedded knowledge is not an individual but a group of people, which we call the knowledge group. The transfer of embedded knowledge, therefore, is a process of adopting the embedded knowledge carried by the knowledge group of the source organization, which we call the source group, into the knowledge group of the recipient organization, which we call the recipient group. In other words, embedded knowledge cannot be effectively transferred in an individual-to-individual manner. Instead, effective transfer must be carried out by the effort and interaction between the source group and the recipient group.
This implies two requirements for effective transfer of embedded knowledge: First, teaching should be done by the many members of the source group in which the capability or routine in question is embedded. Second, learning needs to be carried out by many members of the recipient group, to which the capability or routine in question will be transferred. In other words, embedded knowledge can only be transferred effectively in a group-to-group manner.

**Requirements based on attributes of the source and the recipient organizations**

Transfer of capabilities from MNEs in the developed countries (DCs) to their partners in the LDCs has different implications from the DC-to-DC transfer of capabilities in three aspects. First, larger technological and managerial gaps tend to exist between the source and the recipients organizations. Second, host country environments are usually more complex and dynamic in LDCs (Luo and Peng 1999). Third, the cultural distance between the source and the recipient organizations are usually greater in LDCs.

Therefore, two additional requirements are needed for the DC-to-LDC capability transfer: First, the cultural, managerial distance between the source and the recipient must be reduced. To achieve this reduction, previous host country experience, multinational experience, and alliance experience of the source organization and the IJV experience of the recipient organization can be of great help (Dunning 1988; Johanson and Vahlne 1977; Kogut and Singh 1988; Luo and Peng 1999; Anand and Khanna 2000).

Second, the recipient’s preexisting routines must be ‘unlearned’. This is because the large technological and managerial gap between the source and the recipient organization entails obsolescence of the recipient organization’s preexisting routines. Therefore, capability transfer implies drastic modification rather than incremental change of these obsolete routines. Due to the path dependency of the existing routines, drastic modification of recipient organization’s existing routines is much difficult to carry out than transferring routines to a “clean slate” organization with no previous routines (Baum, 1988; Leonard-Barton, 1992; Argote, 2000), because the former requires one more task in the transfer process: unlearning the previous routines.

**4. Network theory and its implication in capability transfer**

Granovetter (1985) argues that virtually all economic behaviors in modern life is embedded in networks of social relations that condition economic process. Network ties entail mutual influence between an organization and its network contacts in terms of information, power, resource, and trust. Such ties provide benefits such as trusting relationships, fine-grained, timely
and continuous information sharing, and joint problem-solving arrangement (Granovetter 1985; Burt 1992; Ahuja 1996; Powell, Koput and Smith-Doerr 1996; Uzzi 1997; Gulati 1998).

The network perspective has two general implications on the capability transfer process. First, intra-firm networks provide greater *knowledge stocks* through initial endowments and continuous supply of experiences and knowing entities (i.e., personnel) to their member organizations. Network ties, especially intra-firm ties, enable fine-grained, stable, and timely knowledge flows and thereby expand the knowledge stock of each member of the network beyond its organizational boundary (Grant and Baden-Fuller 1995; Gupta and Govindarajan 2000). Previous studies in organizational learning in IJVs focus mostly on the individual organizational experience, though, without considering the knowledge-pooling effect of the MNE’s subsidiary network (Luo and Peng 1999). This study aims to include the knowledge stocks of both source and recipient’s business network to account for their teaching and learning abilities.

Second, alliance inter-partner networks construct an enduring, intimate and timely *knowledge infrastructure* allowing tacit and embedded knowledge contents of the capability to be transferred effectively. Most previous studies in international technology transfer dealt with the transfer interface as a discrete and organization-to-organization conduit. This study, however, using the network perspective, takes the transfer interface as a *network of conduits* to reflect the continuous and group-to-group nature of capability transfer.

To sum up, the network-related concepts of network knowledge stock and network knowledge infrastructure can shed new light in understanding the source organization’s teaching capability and the recipient organization’s learning capability. The network connecting the source and recipient organizations of R&D capability transfer activities can meet the requirements for transferring collective knowledge by providing enduring and intimate ties and group-to-group transfer processes. The knowledge stock of intra-firm networks of both the source and the recipient organizations can help reduce the cultural, managerial, and technical barriers between those two organizations in a DC-to-LDC empirical setting.

In the following sections, we will discuss three networks involved in each case of transfer of R&D capabilities – the source organization’s business network, the recipient firms business network, and the bridge network connecting the source and the recipient organizations. We will also consider the effect of each of these networks on the effectiveness of R&D capability transfer. Figure 1 shows all agents involved in the R&D capability transfer activities studied in this paper.
and knowledge transfer ties among these agents. The figure also depicts the ties that belong to each of the three networks.

*************** Figure 1 about here ***************

4.1. The source organization’s business network

From a network perspective, the source organization, which is the MNE partner of the IJV in the empirical context of this study, can be seen as a member of the source organization’s business network. We refer to this as the source network, which is the MNE subsidiary network of the source organization. The source organization itself can be either the MNE’s parent firm (including the core R&D unit), or a subsidiary unit (including R&D branches).

The source network’s local knowledge stock

Previous evidence suggests that tacit and procedural knowledge in areas such as product and process design, distribution, and marketing circulate among members of MNEs’ subsidiary network (Gupta and Govindarajan 2000). MNE subsidiaries also share alliance management knowledge through the usage of formal knowledge codifying and sharing routines, central administrative entities to coordinate subsidiaries, and corporate database and newsletters on alliance activities (Anand and Khanna 2000).

Evidence from our field observation shows that MNE networks also circulate country-specific and partner-specific knowledge among their members, and provide best practices in transferring technologies and building relational capital with a particular partner in a particular country. Therefore, with sufficient inter-subsidiary knowledge sharing mechanisms, the source network’s knowledge stock regarding alliance capabilities and the local knowledge of the host country and the partner firm can be seen as ‘quasi-public goods’ for all members of the source network. Such public goods enhance the source organization’s teaching capability through reducing managerial and cultural distance between the source and recipient organizations. In other words, the source organization’s teaching capability is embedded in the knowledge stock of the entire source network rather than existing simply within the source organization’s own boundary. This leads to the first proposition.

Proposition 1.1 The greater a source network’s local knowledge stock, the greater the source organization’s teaching capability and the more effective the transfer of R&D capabilities.

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4 Subsidiary units conventionally are defined as business units in which a parent firm holds 50% or more of the equity share.
The source network’s global R&D knowledge stock

The source network’s global R&D knowledge stock, which is carried by its global R&D or engineering branches, also provides a reservoir of R&D localization experiences. The global knowledge also will contribute to the teaching capability of the source organization.

**Proposition 1.2** The greater a source network’s global R&D knowledge stock, the greater the source organization’s teaching capability and the more effective the transfer of R&D capabilities.

4.2. The recipient organization’s business network

In the empirical context of this study, the recipient organization is the local partner of the IJV. A recipient organization’s business network, which we refer to as the recipient network, consists of the parent or core firm and all subsidiaries of the recipient organization. The recipient organization can be either a parent firm or a subsidiary.

Usually, a recipient network as a whole is not entitled to receive technologies or capabilities from the source organization. Nonetheless, it is still important to study recipient networks in the capability transfer process, because they can influence the recipient organizations in two ways. First, a recipient network can significantly influence the initial knowledge stock of the recipient organization through appointing key managerial personnel and transferring employees, which may lead to the transfer of a well-preserved set of routines carried by those managers and employees. The initial endowment of routines and experiences has great significance in the recipient’s absorptive capacity and core rigidity. Second, a recipient network can influence the recipient organization in an ongoing manner through informal personal ties, personnel rotation, and knowledge sharing among all units within the recipient network. Therefore, we include recipient networks in this study and consider a recipient as a member of the recipient network.

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3 In the empirical context of this paper, the recipient networks are also commonly referred to as Chinese business groups. Most Chinese auto firms are involved in business groups. Keister (1998) provides a good description of Chinese business groups.

6 For each IJV we observed in the field, there is a technology transfer agreement, which strictly restricts the recipient of the technology from spreading the technology to its Chinese parent firms or other members of the recipient network. Thus, recipient networks are not the intended recipients of the MNE partner’s capability transfer.

7 According to the Law of the People’s Republic of China on Joint Ventures Using Chinese and Foreign Investment, Chinese personnel appointed by the Chinese parent firms must hold some of the key positions in the IJVs.
Recipient network’s stock of previous R&D experiences – Core rigidity or absorptive capacity?

Given that a recipient network affects the initial endowment of R&D routines through R&D personnel transfer, the learning capability of the recipient organization will be influenced by the recipient network’s previous R&D knowledge stock. This effect will be moderated by the way in which the R&D personnel are transferred from the recipient network to the IJV.

There are two common notions concerning the effect of preexisting organizational knowledge on firms’ capability to learn. The first notion is that preexisting knowledge stock serves as *absorptive capacity* and enables the possessing organization to learn new knowledge more effectively if the new knowledge builds incrementally on the previous knowledge stock (Cohen and Levinthal 1990). The second notion is that the preexisting knowledge stock acts as *core rigidity*, which impedes the firm from learning new knowledge when the environment changes disruptively and renders the knowledge stock obsolete (Levitt and March 1988; Leonard-Barton 1992; Baum and Ingram 1998). The thread connecting both these notions is that group-embedded knowledge of the organization, although it can be modified incrementally, is very difficult to change in a disruptive manner. Preexisting tacit and embedded routines (i.e., collective knowledge) can become core rigidities when they conflict with routines that the firm wishes to acquire. As Dorothy Leonard-Barton puts it “Values, skills, managerial systems, and technical systems that served the company well in the past and may still be wholly appropriate for some projects or parts of projects, are experienced by others as core rigidities – inappropriate sets of knowledge” (Leonard-Barton 1992: 118).

The notions of absorptive capacity and core rigidity only capture the effect of the group-embedded knowledge on the recipient’s capability to learn. What then is the effect of the preexisting technical and managerial experiences that individuals of the recipient organization carry? We argue that these individual experiences form *individual absorptive capacity* and can help the recipient organization to learn more effectively even when the environment changes disruptively and the group-embedded routines have created core rigidities. This result occurs because individual-carried knowledge is much less inertial than the group-embedded knowledge in the time of disruptive change. In general, we argue that when facing a disruptive change, existing group-embedded routines/capabilities act negatively to the transfer of new routines/capabilities, whereas preexisting knowledge set carried individually can help the acquisition of new knowledge and new routines.
As we discussed in section 2, the collective knowledge that encompass R&D capabilities are carried by a knowledge group. Therefore, the capabilities can be disrupted or eliminated when the knowledge group is drastically disrupted. Levitt and March (1988: 328) cited a study by Sproull et al. (1978), which indicates that old routines may weaken when many new members join a group. This indicates that the recipient organization can take advantage of the individual absorptive capacity of the experienced personnel when it transfers R&D personnel from its network. At the same time, the recipient organization may avoid inheriting undesirable routines, which act as core rigidities, by avoiding large-scale organizational transplantation.

When new knowledge presents a drastic change from the preexisting knowledge, if the recipient organization can import the individual absorptive capacity of experienced R&D personnel from the recipient network without inheriting the core rigidity through transferring the knowledge group of the recipient network’s old R&D routines intact, then the recipient network’s previous R&D stock will improve the effectiveness of R&D capability transfer of the IJV. Figure 2 depicts the logic of this argument.

*********** Figure 2 about here ***********

Proposition 2.1  The way in which a recipient network transfers R&D personnel to the recipient organization moderates the effect of the recipient network’s R&D experience on the effectiveness of R&D capability acquisition. The effect will be negative if the personnel transfer involves a large-scale organizational transplantation, while the effect will be positive if the transfer emphasizes individual movement.

The recipient network’s stock of IJV experiences

Recipient networks circulate best practices of transferring knowledge from their foreign IJV partners among the members of the recipient network. We define the recipient network’s IJV knowledge stock as total country-specific and partner-specific experiences among all members of

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8 In the context of IJVs in Chinese automotive industry, many recipient networks’ R&D routines are inefficient. Therefore, if transferred to the IJV’s R&D units, these routines will act as core rigidities and negatively affect the acquisition of new R&D routines from the MNE partner.
the network in doing business, acquiring technologies and building relational capital with this partner or other MNE partners. We suggest the following proposition.

**Proposition 2.2** The greater a recipient network’s IJV knowledge stock, the higher the recipient organization’s learning capability, thus the more effective the transfer of R&D capabilities.

### 4.3. The Bridge network

In addition to the intra-firm networks of the source and recipient organizations, the attributes of the individual-level network at the interface between the source and recipient organization, which we call the bridge network, also affect the effectiveness of the R&D capability transfer. An effective bridge network provides enduring and intimate ties and group-to-group transfer processes, as we discussed in section 3.2.

We define the bridge network as a knowledge transfer network consisting of all employees of both source network and recipient organization involved in joint R&D tasks. The ties of this network are person-to-person, durable, timely, and fine-grained knowledge exchange relationships between the personnel of the source network and personnel of the recipient organization. The personal ties between the learning individual and the teaching individual may outlast the time period of their direct interaction. For instance, a learning individual may come back to the IJV after on-site training at the source organization’s home site, but information can still flow through the personal ties this learning individual developed during the training period.

The bridge network transfers information both from the source (usually the MNE) to the recipient and in the opposite direction. MNE expatriates can learn from their local partners and teach the parent MNE about tacit and organization-embedded knowledge, values, and norms of

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9 Learning studies have identified several types of experience: (1) operating experience, (2) competitive experience, (3) collaborative experience, and (4) foreign entry experience. Here, the IJV knowledge stock refers to the collective collaborative and foreign entry experience stock of the source network.

10 In this empirical context, the ties of bridge network include three types. (1) Ties between a source organization’s international service personnel (ISPs) and Chinese employees of the IJV. ISPs usually take on the boundary spanners’ positions at the joint R&D center, bring in the latest practices and technologies, and have the know-who and authority to call for experts from home knowledge groups to help solve problems that arise in local R&D tasks. (2) Ties created by short-term visits and rotations of experts/managers from the source network who have high information centrality at various units within the source network to the recipient organizations. A Chinese manager noted that “behind these ISP and short-term expatriates is a large network of expertise from the source organization”. (3) Ties created by sending Chinese IJV employees to the core firm or subsidiaries of the source network for on-the-job training.
how things work in the recipient site or country. Such transfer reduces culture differences and incorporates local knowledge in the MNE’s adaptation of R&D capabilities. The bridge network can also help experts in the MNE’s knowledge group to understand the needs and learning capabilities of the IJV’s local employees. In addition, the bridge network can provide the MNE’s employees with knowledge about technological level of the IJV partners. Therefore, the bridge network carries a two-way flow of understanding between the two partner organizations. However, local knowledge flow often declines following the initial period in which the MNE learns key elements of local knowledge, whereas the technical knowledge flowing from the MNE to its IJV must continue over long periods. That is, the importance of the flow from the Chinese parent firms to the MNE tends to be less enduring than the flow of information from the MNE to the recipient. In this paper, we will only focus on the latter knowledge flow.

**Intensity of the bridge network**

Network intensity, generally conceptualized as the frequency of interaction among members of the network, can be measured differently depending upon research focus. Conventionally, the intensity of an information network refers to the frequency of information exchange through its ties. However, when considering transfer of R&D capabilities or collective knowledge as the focal function of the bridge network, the network intensity relates to the frequency of interactions between the transferors and transferees through which the R&D capabilities develop at the transferees’ site.

There is no such isolated act as pure transferring of capability. As theorists have pointed out, the collective knowledge content of routines or capabilities is the organizational memories of experiences, and can only be acquired cumulatively through doing (Levitt and March 1988; Nelson and Winter 1982). To acquire R&D capabilities, the recipient needs to perform tasks that carry direct purposes, such as developing a new product or modify an existing design. When performing these tasks, experiences for coordinating different knowledge ingredients are developed through either unintentional trial and error or intentional searching and teaching. Then, through organizational interpretation systems, some of these experiences become routinized and become capabilities of the recipient (Levitt and March 1988). Therefore, the outcomes of the joint R&D tasks are twofold: physical outcomes, such as new products and design modifications, and capability outcomes, such as increased R&D capabilities of the recipient organization. Transferring R&D capabilities is, in fact, a process of exposing the personnel of the recipient
organization to R&D tasks, and then allowing them to accumulate the knowledge coordination and recombination experiences and store these experiences into a collective memory of how to perform these tasks effectively and efficiently. Without R&D tasks for the recipient to practice, R&D capabilities cannot be transferred.

In addition to the requirement of the availability of R&D tasks for the recipients, there is also a requirement for how these tasks should be carried out. In order to enable the tacit-to-tacit transfer of R&D experiences, substantial interactions between the source and the recipient firms is essential and apprenticeships must be developed (Polanyi 1962; Nonaka and Takeuchi 1995). Therefore, to effectively transfer R&D capabilities, sufficient amounts of R&D tasks must be performed jointly between the learner and the teacher. The intensity of the bridge network will reflect the number of joint R&D tasks the source and the recipient organizations perform\(^\text{11}\).

**Proposition 3.1** The greater the intensity of a bridge network the more effective the R&D capability transfer.

**Scope of bridge network**

The scope of a network usually indicates the array of agents involved in the network. Since, in this empirical context, the main purpose of the bridge network is to transfer collective knowledge underlying R&D capabilities, the scope of the bridge network will reflect the scope of the source groups of the source organization and recipient groups of the recipient organization.

\(^{11}\) It is understandable that at the early stage of acquiring R&D capabilities, the recipient will not be entrusted with full-blown R&D projects for real market purposes, even with the assistance of expatriates from the source firm. In the auto industry, R&D projects involve many different levels of difficulty. The most extensive R&D activity is the development of a new platform, which includes styling, redesign of power train and key subassemblies and components. This kind of project usually costs more than a billion dollars for each platform and needs production volume exceeding a million vehicles a year to recover the R&D costs. Obviously, this is not a feasible starting task for the recipient firm to work on. And in reality, the source organizations, usually MNEs from the industrialized countries, have no intention to hand over knowledge of this kind of activity to their partners in LDCs. The realistic tasks for both the recipient and the source firms lie in the R&D activities with lower degree of difficulty and narrower scope. Most joint R&D tasks between local recipients and the multinational source firms in the Chinese auto sector limit themselves to recombining local knowledge with the MNE’s general knowledge, that is, to carry over an existing platform developed by the MNE and modify the style, adjust dimensions, and parameters of some components based on local customer taste, driving conditions, and government regulations. This type of task, although relatively simple, still calls for a great deal of coordination among functional groups such as marketing, analysis, design, prototype, validation, and production. Engaging in these tasks can expose the recipients to a large portion of R&D routines and different stages of R&D process.
As we discussed in Section 3.2, a knowledge group is the indivisible carrier for a certain level of routine. Therefore, capabilities can only be transferred effectively in a group-to-group manner, rather than in an individual-to-individual manner.

“… it will often not suffice just to transfer individuals. While a single individual may sometimes hold the key to much organizational knowledge, group support is often needed, since organizational routines may need to be transferred.” (Teece, 1986 :29)

“Although organizational learning occurs through individuals, it would be a mistake to conclude that organizational learning is nothing but the cumulative result of their members’ learning. Organizations do not have brains, but they have cognitive systems and memories. As individuals develop their personalities, personal habits, and beliefs over time, organizations develop worldviews and ideologies. Members come and go, and leadership changes, but organizations’ memories preserve certain behaviors, mental maps, norms and values over time.” (Hedberg, quoted by Fiol and Lyles 1985)

This argument implies two key elements for effective R&D capability transfer: **teaching by the source group** and **learning by the recipient group**. Teaching by the source group refers to the exposure of each learner of the recipient organization to the relevant teaching group of the source organization in order for him/her to acquire collective knowledge through observing and participating in the group interaction and coordination routines among different knowledge carriers in that source group. In addition to obtaining tacit, group-embedded technical knowledge, becoming embedded in the source group also enables the learners to experience the organizational environment and tacitly acquire the values, beliefs and norms of the transferor’s knowledge group. This resembles a socialization process (Nonaka and Takeuchi 1995).

Since the tacit and group-embedded R&D routines may span different functional groups and across different R&D stages, we define the scope of a source group that carries a certain R&D capability in two aspects: functional scope and temporal scope of a source group. Functional scope refers to the range of the source organization’s functional divisions, while temporal scope refers to the range of the source organization’s R&D phases with which the transferees of recipient organization have worked and obtained on-the-job training. We suggest the following propositions.

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12 For instance, an engine design team within an R&D center is a knowledge group that carries the routines/capabilities to engine design, whereas a platform design unit is a higher-level knowledge group that contains the routines/capabilities to integrate engine, transmission, and other subassemblies into a vehicle platform. Within an MNE, all of the R&D branches of its various subsidiaries form the highest level of R&D knowledge group. These different levels of knowledge communities are sometimes intertwined through matrix organization design and personnel transfer.
**Proposition 3.2a.** The more the functional scope of a source group matches the functional scope of the technical or managerial skills that each R&D personnel of the recipient organization is intended to acquire, the more effective the R&D capability transfer.

**Proposition 3.2b.** The more the temporal scope of a source group matches the temporal scope of the technical or managerial skills that each R&D personnel of the recipient organization is intended to acquire, the more effective the R&D capability transfer.

In addition to gaining tacit and embedded knowledge from the source group, a learner from the recipient organization also needs to incorporate the acquired R&D related experiences through collective memory formation process in the recipient group (Levitt and March 1988). The collective memory process is needed because the final goal of R&D capability transfer is to form R&D related knowledge coordination and collaboration routines among the employees in the recipient organization. The collective memory of R&D experiences must be developed among the learners by working and learning together as a group. This is what we call *learning by the recipient group*.

In an experiment of group training, Liang et al. (1995) found that training employees in their work groups as a whole is more effective than training the employees individually. The results indicated that group training improved group performance primarily by fostering the development of transactive memory systems among group members, which is a similar concept as the collective memory or collective knowledge. We define the *scope of the recipient group* as the range of interaction in the group learning process among trainees who are expected to gain and carry certain routines. We suggest the following proposition.

*Proposition 3.3 The more the scope of the recipient group matches the scope of the technical and managerial skills needed for performing the desired R&D tasks, the more effective the R&D capability transfer.*

Thus, we propose that the most effective R&D capability transfer process requires the learning individuals to learn from the relevant source group as a whole, and to learn with the relevant recipient group as a whole.

**IT infrastructure**

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13 Transferring R&D capabilities from one firm to the other appears similar to on-the-job training of new employees, but in fact has fundamental differences: (1) transferring R&D capabilities entails a learning group not just learning individuals, and (2) new employees are inherited with the existing operational context, whereas R&D capability recipients are expected to develop a new operational environment during their learning process.
In addition to collective knowledge content, R&D capabilities involve codifiable knowledge content, such as design, data, written instructions, that can be transferred more effectively and accurately through electronic means of communication than through direct human contact. IT infrastructure also allows group-to-group communication through teleconferences or group electronic mails. Therefore, some articulatable and group-embedded knowledge (i.e., objectified knowledge) can also be transferred through IT infrastructure. Nonetheless, IT infrastructure is only effective when the partners have already developed a communication relationship through direct contacts (Argote and Ingram 2000). In other words, direct interactions between partners are the prerequisite for the effective usage of the IT infrastructure and cannot be substituted by the IT infrastructure in transferring knowledge.

Proposition 3.4 The more effective the IT infrastructure within a bridge network, the more effective the transfer of codifiable and articulatable contents of R&D capabilities. This positive effect is conditional upon the intensity of the bridge network.

Formal training

As we discussed in Section 4.2, individual absorptive capacity can help the recipient organization to learn more effectively even when the environment changes disruptively and the group-embedded routines have become core rigidities. One way to increase individual absorptive capacity of the personnel from the recipient organization is through formal training in modern technology and managerial skills.

Although the core component of R&D capabilities is collective knowledge, portions of R&D capabilities re codified into written documents and spread throughout the public domain. The public parts of R&D capabilities include fundamental technical and R&D managerial knowledge that every R&D personnel should acquire before they engage in R&D tasks. Formal training is effective in improving the technical and managerial literacy of the personnel of the recipient organization, and thereby increasing individual absorptive capacity in the R&D capability transfer process.

Proposition 3.5 The greater the proportion of a recipient organization’s R&D personnel that has received formal training in technical or managerial knowledge related to their R&D projects, the more effective the R&D capability transfer.
In summary, effective R&D capability transfer depends on the local knowledge stock and the global R&D knowledge stock of the source network, the IJV and R&D knowledge stock of the recipient network, and the initial endowment of R&D routines of the recipient organization. These network knowledge stocks serve to reduce the cultural, technical, and managerial distances between a source organization from a DC and a recipient organization from a LDC.

Furthermore, the transfer of R&D capabilities is an effort involving not just the stylized single-channel and discrete knowledge flow between the source and the recipient organizations, but a lasting web of direct ties between the personnel of the source network and the personnel of the recipient organization. Capabilities or routines must be acquired through learning-by-doing, teaching-by-the-source-group, and learning-by-the-recipient-group. A bridge network provides mechanisms that can satisfy the requirement for transferring collective knowledge if its intensity and scopes are designed properly. Other supplementary capability transfer mechanisms such as IT infrastructure and formal training can enhance the direct interactions of a bridge network, but are not capable of substituting for the bridge network. Figure 3 depicts the logical linkages between network-related factors and the effectiveness of the R&D capability transfer.

5. Empirical context and methodology

5.1. Empirical context

As we noted earlier, we selected the activities of transferring R&D capabilities in Chinese auto industry as the empirical setting for this study. There is growing evidence of MNE’s transferring R&D capability to their joint ventures in this industry. Moreover, there are significant technological, cultural, and managerial distances between the source organizations, which are foreign MNEs, and the recipient organizations, which are the IJVs of the MNEs in this industry. This large asymmetry between the two alliance partners indicates substantial potential for inter-partner learning (Dussauge, Garrette and Mitchell 2000). The industry provides a natural setting for studying how firms apply their network knowledge stock and design their inter-partner network structure to overcome transfer difficulties and achieve effective capability transfer.

When China’s auto industry opened to foreign investors in the early 1980’s, its R&D capability in passenger car sector was weak. State owned enterprises (SOEs) in this sector were initially formed to produce commercial vehicles rather than passenger vehicles. SOEs were
characterized by low R&D effort (R&D spending was less than 1% of revenue, far lower than R&D by MNEs) and long platform upgrade cycles (usually longer than 20 years).

The auto industry is considered a pillar industry by the Chinese government. Chinese industrial policy gives strong emphasis on developing indigenous R&D capabilities. The approval guidelines for foreign MNEs’ to establish IJVs in the Chinese auto industry involve several key provisions concerning technical development (The State Administration of Machinery Industry 1995). The IJV must have an internal technical center, which is capable of developing future generations of products. Moreover, the products of the IJV must quickly reach global technological level of the 1990’s. The industrial policy makers of this industry also gave strategic guidelines for developing indigenous R&D capabilities (The State Administration of Machinery Industry 1995): (1) vehicle OEMs should take 5% to 10% of total reinvestment into developing or expanding their tech centers; (2) R&D spending should reach 2% to 3% of sales; and (3) key component suppliers should apply 10% to 20% of their reinvestment to set up their R&D facilities and technical centers. The government also provides financial and taxation support for joint R&D projects among business groups.

MNEs have recognized the potential of the emerging car market in China since the early 1980’s. AMC-Jeep and VW were the first two MNEs to enter China. They entered with cautious attitudes about the industrial infrastructure and local market, and only established simple vehicle assembly facilities with low local content and near-to-zero local knowledge content. The big commercial success of VW in the late 1980’s and early 1990’s evoked a stride of inflow of foreign investment in both vehicle OEM and supplier sectors. In order to earn the approval of entering China, MNEs now must commit to bring in modern product/process technologies and help develop indigenous R&D capabilities at their local operations.

China’s demand for R&D capability transfer does not necessarily contradict with the long-term vision of MNE investors. As competition in the host countries’ markets becomes more global and intense, new products that suit local tastes and regulations need to be developed at a faster pace. Transferring R&D capabilities to operations close to local markets then becomes more beneficial (Buckley and Casson 1976). MNEs’ R&D activities in the LDCs are mostly at the end stage of the R&D cycle, with tasks such as adapting the general design to the local environment.14

14 The design adaptation/localization process takes varying degree of local knowledge content, ranging from extending the length of the car to re-designing the exterior and interior and fitting a new engine. GM-Shanghai, for example, made 600 engineering
validating the product capability of local supplier, and validating the localized product design to meet the quality, safety and environmental requirements.

5.2. Methodology and samples

We took a qualitative approach for this study. We conducted semi-structured and open-ended interviews based on a preliminary framework with fourteen respondents from four IJVs in Chinese auto industry, each of which has on-going R&D capability transfer programs. These respondents represent either Chinese or foreign partners of the IJVs, and all assume high responsibilities in R&D management. We also interviewed four government officials from government agencies that are in charge of automotive industry and technology management. All interviews were conducted in either English and Chinese as appropriate, with each interview last at least two hours. We also conducted field observations at the joint R&D centers and manufacturing plants of these four IJVs. In addition, we collected documents with regard to these IJVs’ strategies, structures, activities and performances. We then refined the initial theoretical framework as the study proceeded. Although the firm-level sample size is four, the sample covers almost all major original equipment manufacturers (OEMs) in the Chinese automotive industry that are involved in full-scale R&D capability transfer projects.

The rationale for using the qualitative approach lies in the following aspects: First, the intent of this study is to explore new theoretical ground. Second, the propositions of this paper deal with detailed firm-specific constructs that cannot easily be obtained and analyzed with quantitative methods. Third, the in-depth fieldwork can reveal managerial intentions and causalities of the issues related to R&D capability transfer (Yin 1981; Strauss and Corbin 1990; Rouse and Daellenbach 1999; Capron and Mitchell 1999).

6. Results

Table 1 outlines the results of the interviews, discussions, and field observations. The study took place at the initial stage of the R&D capability transfer projects within the sample IJVs. Therefore, the results reveal more about the strategic choice of mechanisms for the transfer projects than about the effectiveness of these mechanisms. Since transfer of R&D capability is a time-consuming process, it will take several years before we can judge the effectiveness of the changes to tailor the Buick Century to Chinese driving conditions and regulations. For instance, the rear seat was elevated, legroom in the back was enhanced, and the suspension was fine-tuned for China’s road conditions.
transfers. Despite these limitations, the results are still important in that they provide evidence for the face validity of the propositions. The observations of strategic choices of the parties in this study reflect the perceived effectiveness by the practitioners based on their past experiences at the initial stage of the current transfer project and other similar transfer projects. The actual effectiveness, which is the overall evaluation of the effectiveness, will need to be judged at the later stage of the R&D capability transfer process. Since the perceived effectiveness and actual effectiveness are likely to correlate, the current results help predict actual effectiveness.

In general, the results are consistent with the propositions, as Table 1 outlines.

********** Table 1 about here **********

6.1 Consistencies

Two different interviewees from the two partners of an IJV noted that the presence of greater stocks of both local knowledge and global R&D knowledge within the source network led to improved R&D capability transfer. These comments, together with comments concerning business practices by interviewees from other IJVs, support Proposition 1.1 and 1.2.

With regard to Proposition 2.1, we found that most interviewees raised the importance of recruiting and retaining engineers with previous R&D experience and good educational background. Moreover, two of the interviewees raised a concern about the negative effect of transplanting or adopting an entire R&D unit from the Chinese partners' business groups into the IJV. These comments support the mixed effect of recipient groups' previous technical knowledge stock on R&D capability transfer addressed in Proposition 2.1.

A technical manager of an MNE, meanwhile, compared the R&D capability learning of two of the MNE's Chinese partners, which belong to different business groups. He accredited the better performance of one Chinese partner to support from its business group, which has a more IJV experience than the other partner's business group. This comparison is consistent with Proposition 2.2, that the recipient group's IJV knowledge stock has positive impact on the effectiveness of R&D capability transfer.

In several interviews, managers from IJVs' local partners noted the importance of learning-by-doing in joint R&D projects. The comments are consistent with the positive effect of bridge network intensity on R&D capability transfer in Proposition 3.1.

With regard to the effect of learning from the source group that Proposition 3.2 raises, there were few comments from the interviewees. Nonetheless, a Chinese technical manager who
has been through extensive overseas training indicated that the most beneficial aspect of learning overseas at the source organization's home site was to be able to work with and learn from people in different function groups, while participating in multiple R&D phases. This discussion provides some evidence consistent with proposition 3.2.

Among the IJVs we interviewed that have overseas on-site training programs, most sent the Chinese trainees in groups. For example, one MNE with relatively long Chinese IJV experience sent 40 Chinese trainees as a group to its home site for long-term on-the-job training. This supports Proposition 3.3, that learning-as-a-group may have positive effect on R&D capability transfer expectations.

Moreover, most interviewees stated that both information technology and formal training had positive effects for their R&D projects. The comments are consistent with Propositions 3.4 and 3.5.

In general, then, we found evidence in the field that was consistent with each proposition. Moreover, most of the respondents’ comments aligned with the predictions of the model.

### 6.2 Inconsistencies

Despite the overall consistency, a few observations and comments were inconsistent with our expectations. For instance, one IJV successfully completed a new vehicle model design within two years despite the lack of prior large-scale joint R&D projects, contrary to Proposition 3.1, which predicted that greater intensity of a bridge network would lead to greater effectiveness of R&D capability transfer. A manager from the local partner, who participated in this design project, credited the success largely to the foreign partner’s openness with knowledge sharing. Moreover, this design project was somewhat less complex than other projects in the study. This example suggests that other factors, such as the extent of a foreign partner’s involvement in an R&D project and the complexity of the R&D project, can substitute for the positive effect of bridge network intensity.

We also observed that many respondents did not raise the importance of group learning or group teaching, as Propositions 3.2 and 3.3 suggest. Nonetheless, as we noted above, some of the domestic partners did send groups of Chinese engineers for on-the-job training at the MNE’s

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15 This design project adapted an existing compact vehicle platform to fit the tastes of local consumers. The major R&D work included interior and exterior styling, as well as minor modifications of power train (e.g., engine and transmission) systems to meet local regulations and road conditions.
overseas home site. These inconsistencies either indicate that some practitioners did not acknowledge or follow the best practices suggested by the propositions, or suggest that we have not exhausted all causal linkages in these propositions.

7. Concluding points

This paper extends technology transfer studies by considering the process of knowledge transfer through network lenses rather than from the perspectives of isolated source and recipient organizations. The theoretical contributions of this paper lie in four areas. First, we identified the core component of R&D capability – collective knowledge. Second, we systematically identified three networks that are involved in the R&D capability transfer process, including recipient networks, source networks, and bridge networks. Third, we specified network measures that relate to the effectiveness of R&D capability transfer between a source organization and a recipient organization. Fourth, we predicted the impact of these measures of these networks on the effectiveness of the R&D capability transfer, based on the theoretical analysis of the requirements for transferring R&D capabilities.

We found two general aspects of networks – network knowledge stock and network structure – that contribute to the effectiveness of R&D capability transfer. The network knowledge stock of a recipient network can affect the recipient organization’s learning capability, whereas the network knowledge stock of a source network can affect the source organization’s teaching capability. The network knowledge stocks of both partners of an IJV serve to attenuate the cultural and managerial incompatibility and technological gap between them. We partitioned network knowledge stock into a two-by-two taxonomy along two dimensions – technical (or R&D) vs. alliance/local and recipient side vs. source side (Table 2).

********** Table 2 about here **********
organization of the recipient network. We discussed the distinction between the positive effect of the individual absorptive capacity of experienced R&D personnel from the recipient network and the negative effect of the core rigidity embedded among the knowledge groups of the R&D units of the recipient network. We then argued that if a recipient network endows the recipient organization with its core rigidity through large-scale organizational replication, then the recipient organization will encounter more learning cost for unlearning the old routines. In other words, although individual R&D personnel from the recipient network bring individual absorptive capacity to the recipient organization, groups of R&D personnel may carry a highly inertial resistance to the acquisition and implementation of the new R&D routines. In summary, a network knowledge stock has the potential either to enhance or hamper R&D capability transfer, depending up the nature of the stock and moderating effects.

Network structure is the second general aspect of network we discussed. The network structure measures to which we paid most attention are the intensity and scope of the bridge network, where the bridge network is the interface between a recipient and a source organization. The intensity of a bridge network, as measured by the number of jointly performed R&D tasks, manifests the learning-by-doing and learning-by-direct-contact requirements for transferring tacit knowledge. On the other hand, the scope of a bridge network reflects the group-to-group nature of transferring embedded knowledge. Since the core content of R&D capabilities is the knowledge that is both tacit and embedded, the intensity and the scope of a bridge network are both critical measures for the effectiveness of R&D capability transfer.

We believe two theoretical arguments in the paper are particularly central. First, we argue that group teaching (i.e. teaching by the source group) and group learning (i.e. learning by the recipient group) mechanisms are more effective in transferring embedded and tacit knowledge than individual teaching and individual learning mechanisms. Second, we believe that past technical experience of the recipient organization has both positive and negative implications to the effectiveness of its acquisition of new embedded and tacit knowledge. The prior technical experience of individual persons serves as absorptive capacity and positively relates to the effectiveness of the R&D capability transfer, whereas the prior routines embedded in the knowledge groups of the recipient organization act as core rigidity and thus negatively relate to the effectiveness of R&D capability transfer.
The study has three key empirical implications. First, practitioners need to realize that the R&D capabilities can only be transferred through performing R&D tasks. Moreover, the transfer will be more effective if personnel from both sides of the transfer perform the tasks jointly. IT and formal training, although important, cannot replace the learning from performing R&D tasks. Second, it is important that the managers and engineers of the recipient organization learn as a group from the entire knowledge group of the source organization. This usually implies sending a group of engineers from the recipient site to the source site and performing joint R&D tasks. Third, the absorptive capacity of the recipient organization can be enhanced by hiring experienced individuals from the R&D units of the recipient network. However the recipient organization should avoid replicating or adopting the entire R&D units from its network, which are often characterized by obsolete R&D routines.

As an exploratory study, this paper has several limitations. First, we collected data at early stages of the R&D capability transfer process. Therefore, the propositions cannot be fully tested. Only the potential validity of these propositions is confirmed by the initial field data. Second, more fine-grained network measures such as network centrality and density are not taken into account. Third, we have omitted the motivational factors for R&D capability transfer in order to undertake a focused study on the coordination factors for R&D capability transfer.

Several extensions of this study are possible. We hope to include other network factors such as network centrality and density into the theoretical framework. We also intend to study the motivational factors for R&D capability transfer in IJVs between firms from DC and LDC. Finally, we plan to consider other industries and other recipient countries to determine whether the results of this study generalize beyond the current empirical setting.
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### Table 1. Supporting Evidence: (For the coding scheme of the interviewees, see the Note at the end of this table)

<table>
<thead>
<tr>
<th>Propositions</th>
<th>Supporting Evidence</th>
</tr>
</thead>
</table>
| **P1.1**     | A-FP-1 talked about the source network of the IJV “A”: “Best practices are frequently communicated among subsidiaries. For example, when establishing the R&D project in our Chinese IJV, we got help from our Australian subsidiary’s product expertise and Polish subsidiary’s expertise in managing IJVs in the transition economies.” When asked about the mechanisms used for the inter-subsidiary communication A-FP-1 mentioned the following:  
  - Regularly use of IT, such as: multimedia conference, data-exchange, e-mail  
  - Personnel visit, exchange and rotation  
  - Higher level managers’ monetary incentive being linked to global growth  
  - Leadership vision in global operations  
  - Personal relationships and informal contacts among leaders of different subsidiaries  
  - Regular meetings and conferences  
  - Internal newsletters and documents  
  Most IJVs that were interviewed take advantage of the source network’s global (especially LDC) operation experiences in the similar way mentioned in the evidence. |
| **P1.2**     | A-CP-1: “Our foreign partner’s R&D branches in Brazil and Australia were heavily involved in the R&D capability development here. They’ve provided assistance with their expertise in transferring and localizing technologies. When we were developing our first passenger car model, our foreign partner’s Australia R&D branch sent several exterior designers and modeling engineers to here and gave us hands-on trainings.” IJV “B”, which has R&D branches in the LDCs also made use of the R&D experience of that branch in its Chinese R&D project. |
| **P2.1**     | B-CP-2: “A lot of our engineers are from the tech center of our Chinese parent firm. When they were in the tech center, they could not achieve any new design. Now, with new organization and advanced management, they developed a new car model based on a advanced chassis system from our foreign partner in only one year.”  
C-CP-1: “Transforming an old R&D unit is much difficult than starting a new one from scratch.”  
A-CP-1: “We have been trying to attract high quality personnel from top-notch universities and other companies to work for us, with high salary and working conditions.” |
| **P2.2**     | A-FP-3 compared the transfer performance between two Chinese partners of A-FP: “[Chinese Partner I] was much more experienced and easier to cope with than [Chinese Partner II]… This difference is due to the fact that [Partner I] has a lot more IJV experience and their managers, engineers and workers understand better about the advanced technologies, managerial procedures, quality standards, and the proper way to interact with us.”  
B-CP-1: “When [IJV “B”] was established, some experienced managers were transferred from the other IJV [B-CP’s] to here per [B-CP’s] request. And you bet that was a great support for us.” |
| **P3.1**     | D-CP-1: “It took us 12 years of learning period before we gain adequate R&D capability to design our own vehicle. We experienced 5 rounds of the failed formal R&D trials before it finally succeeded. All the R&D projects were performed jointly with our foreign partner.” |
either in their site or here.”

C-CP-2: “We tried very hard to win the bid for a face-lifting project for a compact passenger car in order to gain R&D experiences. The tuition is quite worthwhile”

| P3.2 | B-CP-1 who went through an extensive on-job training in the B-FP’s site mentioned: “I did not realize how many knowledge I had missed at home until I came here and worked with many engineers from different department. Learning from the whole system is far more effective than learning from a few individual experts. The most effective way to learn how things can actually get done is to work with different people in different functional groups that are involved in the project. You need to see how each job element is done by individual engineers or groups as well as how they coordinate those job elements. ” |
| P3.3 | B-FP-1: “In order to cultivate [our Chinese JV’s] indigenous R&D capabilities, we’ve sent 40 Chinese engineers responsible for different R&D functions to Germany for on-job training throughout the entire process of vehicle development. The trainees engaged in a six-month study of their own specialty in a German university, and then transferred to [our company’s] vehicle development center to receive on-job training and participated in development projects, which include vehicle platform arrangement, styling, and component design using computer-aided vehicle design systems. These Chinese engineers interact with each other during the learning process. They came home working together on same types of tasks as a cohort.” |
| P3.4 | A-FP-1: “IT is important in technology transfer. Lot of communications between our headquarter and the [Chinese IJV] are done through IT. We have been working on the CAD/CAE software and IT protocol compatibility with all of our global R&D operations. Our goal is to establish a global-engineering system with all R&D branches around the world and be able to leverage the global engineering capacity and perform joint R&D around the clock.” |
| P3.5 | B-CP-2: “We’ve sent many of our Chinese engineers and mangers of to [an independent training center] that teaches technical and project management courses. Some of them complained that the training courses in project management only give them some basics and couldn’t solve their particular problems. But in general, these courses have been helpful in providing the basics. We will continue to do this”

According to our interview with the manager of the above-mentioned training center, many other IJVs have sent their Chinese employees for formal training, in order to improve their technical and managerial literacy.

Note: The interviewees are labeled for confidentiality. The first letter of the code stands for the IJV that the respondent is from; the second and third letters tell whether the respondent is from the Chinese partner side (CP) or from the foreign partner side (FP) of the venture; and the number at the end of a code stands for the rank order of the respondent in its work area. For example, the code “A-FP-1” stands for the first respondent (1) from the foreign partner (FP) of the IJV “A”. The code “C-CP-2” stands for the second respondent (2) from the Chinese partner (CP) of the IJV “C”.

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Table 2. The predicted effects of network knowledge stocks on the recipient organization’s learning capability and the source organization’s teaching capability

<table>
<thead>
<tr>
<th>Owner</th>
<th>Type</th>
<th>Technical (or R&amp;D) Knowledge Stock</th>
<th>Alliance/Local Knowledge Stock</th>
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<tbody>
<tr>
<td>Recipient Network</td>
<td>(Proposition 2.1)</td>
<td>Mixed effect on a recipient organization’s learning capability. Moderated by the extent of organizational replication between the recipient network’s and the recipient organization’s R&amp;D units.</td>
<td>(Proposition 2.2) Positive effect on a recipient organization’s learning capability.</td>
</tr>
<tr>
<td>Source Network</td>
<td>(Proposition 1.2)</td>
<td>Positive effect on a source organization’s teaching capability.</td>
<td>(Proposition 1.1) Positive effect on a source organization’s teaching capability.</td>
</tr>
</tbody>
</table>
Figure 1. Diagram of the three networks involved in R&D capability transfer

- **MNE’s subsidiary**
- **MNE’s parent firm**
- **MNE’s Expatriates to the IJV**
- **Core firm**
- **Recipient Organization**
- **Training Centers**

**Source Network:**
- MNE Business Network

**Recipient Network:**
- Chinese Business Group

**Ties:**
- Dashed lines: Ties of Bridge Network
- Dotted lines: Ties of Recipient Network
- Solid lines: Ties of Source Network
Figure 2. The effect of a recipient network’s stock of previous R&D experience on the effectiveness of R&D transfer in the IJV

* This moderating variable defines the mechanism of R&D personnel transfer from the recipient network to the recipient organization. Large-scale organizational replication means that a large proportion of R&D personnel transfer to the IJV from the recipient network’s R&D units without significant reorganization. In other words, any obsolete R&D routines of a recipient network are transferred intact.
Figure 3. Factors affect effectiveness of transfer of R&D capabilities

**Source network**
- P1.1 Local knowledge stock
- P1.2 R&D experience stock

**Recipient network**
- P2.1 Previous R&D experience stock (moderated by the scale of the organizational replication)
- P2.2 Previous IJV experience stock

**Bridge network**
- P3.1 Intensity
- P3.2 Scope of the Teaching Group
- P3.3 Scope of the Learning Group
- P3.4 IT
- P3.5 Formal training