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Transferring R&D knowledge: the key factors affecting knowledge transfer success

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Abstract

Based on a study of knowledge transfer within more than 15 industries, across three forms of governance, and between both domestic and international R&D partners, knowledge transfer success was found to be associated with several key variables, and to hinge upon (a) both R&D units' understanding where the desired knowledge resides within the source, (b) the extent to which the parties share similar knowledge bases, and the extent of interactions between the source and the recipient to (c) transfer the knowledge and (d) participate in an articulation process through which the source's knowledge is made accessible to the recipient.

JEL classification: L2 (firm objectives, organization, and behavior); L20 (general); L21 (business objectives of the firm)

Keywords: Knowledge transfer; Knowledge success; New product development; Research and development

1. Introduction

When General Motors (GM) found success in its Saturn division, it did not hesitate to seek to transfer some of the insights and best practices learned to its other divisions. Unfortunately, as Kerwin and Woodruff (1992) found, knowledge sharing at GM proved to be like in many organizations, more difficult than expected (Gupta and Govindarajan, 1991a). Indeed, many firms find knowledge transfer to be challenging, although its success

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is often critical in new product development (NPD) related activities (Kazanjian et al., 2000; Purser et al., 1992).

Since NPD activities are exploratory in nature, there is usually a high degree of ambiguity and uncertainty about the knowledge to be transferred. Moreover, knowledge transfer packages are not comprised of only written documents and codified information, as "explicit knowledge must rely on being tacitly understood and applied" (Polanyi, 1966a, p. 7). In addition, as the world's economy and workforce globalize, and companies face increased pressures to build critical mass, reach new markets, and plug skill gaps (Doz and Hamel, 1998), NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements. Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001).

Research on the use of information and communication technologies to bring internationally dispersed R&D teams together bears out the challenges facing virtual NPD projects; while such technologies were effective at facilitating the transfer of codified knowledge, they could not transfer related sensory information, feelings, intuition, and non-verbal communications that were important to the knowledge's ultimate implementation (Boutellier et al., 1998). Similarly, as Lall (2000, p. 15) noted, knowledge embodied in technology "can be used at best practice levels only if [it is] complemented by a number of tacit elements that have to be developed locally". In addition, given that it can be difficult to know exactly what needs to be transferred prior to engaging in a transfer project (Sowell, 1980), it is easy to see how many R&D acquisitions, alliances, and projects fail to fully anticipate the direction of the NPD project or produce their intended results. Operating in a virtual environment may further exacerbate these difficulties.

This paper begins with a brief overview of knowledge transfer research from the technology transfer/innovation and strategic management fields. Based on these research streams, Fig. 1 presents a model of transfer success that includes nine key factors affecting knowledge

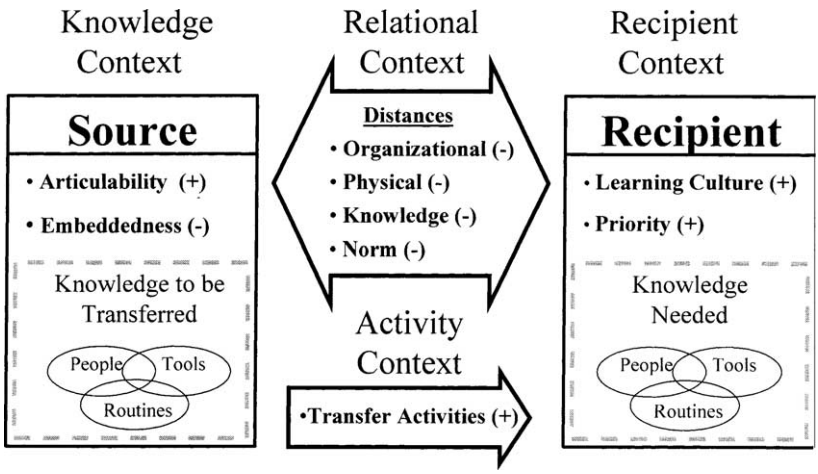

Fig. 1. Research model.

transfer across four broad contextual domains, including knowledge context, relational context, recipient context, and activity context. While some researchers have focused almost exclusively on the knowledge context (e.g. Zander and Kogut, 1995; Winter, 1987), others have focused on the relational context (e.g. Szulanski, 1996; Kostova, 1999), or on the recipient's culture (e.g. Choi and Lee, 1997; Davenport and Prusak, 1998). Although several of these and other studies attempt to integrate a number of these factors, no studies were found that integrated all of these key factors, or that brought together the three different organizational governance modes examined in this study. Following a delineation of the model and related hypotheses, hierarchical regression analysis is used to analyze the data from a recent mail survey questionnaire of R&D managers. The findings suggest a number of key factors that can affect knowledge transfer success, with implications for virtual NPD environments.

2. Successful knowledge transfers

Research on knowledge transfer has developed out of studies focused on how firms could best accomplish international technology transfers to facilitate pursuit of Vernon's (1966) product life cycle. Early studies found that transfer costs decrease with experience (Mansfield et al., 1979; Teece, 1976, 1977) and examined the speed through which firms are able to first develop and then transfer innovations to subsidiaries (Mansfield and Romeo, 1980; Davidson, 1980). Early conceptual work focused on the role of administrative structures on knowledge flows to and from the rest of the corporation (Bartlett and Ghoshal, 1986). Birkinshaw and Morrison (1995) found that firms with organizational structures that supported combining activities and sharing resources across subsidiary boundaries were more innovative.

Research on knowledge transfer has also focused on inter-firm governance modes as well, including transfers in alliance settings and from acquired units. Simonin (1999) empirically examined the antecedents to marketing knowledge ambiguity in strategic alliances. Others (e.g. Inkpen, 1996, 1997; Khanna et al., 1998) have addressed broad issues in the management of knowledge in alliances. Doz (1996) and Simonin (1997) examined the impact of collaborative experience as a form of knowledge developed between alliance partners. Hu (1995) investigated the transferability of a firm's competitive advantage across international borders. Dodgson (1996) investigated the impact of trust and inter-firm technological linkages on knowledge transfer. Moreover, according to Simonin (1999), researchers have focused on other firm-specific variables that can affect knowledge transfer, such as strategic intent and motives, organizational capabilities, partner selection, and trust. With respect to knowledge transfer in acquisition settings, on the other hand, only Bresman et al.'s (1999) study was found.

Regardless of the setting, the objective of any knowledge transfer project is to transfer source knowledge successfully to a recipient. Researchers have used four different approaches to define transfer success as a dependent variable. At the most basic level, transfer success was defined as the number of knowledge transfers engaged in during a certain period of time (Hakanson and Nobel, 1998). A second approach, this one drawing on the project management literature (Pinto and Mantel, 1990), defined a successful transfer as one that

is on time, on budget, and produces a satisfied recipient (Szulanski, 1996). This approach was used with a communications model (Rogers, 1983) to identify the factors that can make knowledge transfers 'sticky'.

A third approach to defining knowledge transfer success, this one from the technology transfer and innovation literature, focused on the degree to which the knowledge is *re-created* in the recipient. In this literature, successful knowledge sharing results in firms mastering and getting into practice product designs, manufacturing processes, and organizational designs that are new to them (Nelson, 1993), and knowledge transfer is seen as occurring through a dynamic learning process where organizations continually interact with customers and suppliers to innovate or creatively imitate (Kim and Nelson, 2000). From this perspective, knowledge transfer involves the re-creation of a source's knowledge package in the recipient. The problem with this replication approach is that knowledge can be embedded in many different structural elements of an organization, such as in the people and their skills, the technical tools, and the routines and systems used by the organization, as well as in the networks formed between and among these elements (Argote and Ingram, 2000). Since it is often difficult to know which elements (e.g. people, tools and routines) comprise a source's knowledge package (Spender and Grant, 1996), assessing replication is difficult. Moreover, there is significant evidence that effective re-creation also requires that the knowledge package is made accessible to or de-contextualized for the recipient so that the recipient can convert it, adapt it or reconfigure it to its localized needs (Devadas and Argote, 1995; Dixon, 1994; Leonard-Barton, 1988; Moreland et al., 1996). Thus, even if the elements of the knowledge package can be clearly identified, they may be hard to discern in their adapted forms within the recipient.

A fourth approach to defining transfer success, termed knowledge internalization and adopted in this study, comes from institutional theory (Meyer and Rowan, 1977). It defines success as the degree to which a recipient obtains ownership of, commitment to, and satisfaction with the transferred knowledge. According to Kostova (1999), three factors appear to be related to knowledge ownership. First, greater discretion over the knowledge can allow a recipient to "invest more of their own ideas, unique knowledge, and personal style" in the knowledge (Pierce et al., 2001, p. 301). Second, the intensity of the recipient's association with the knowledge (i.e. the number of interactions involving the knowledge) can affect its feeling of ownership. Lastly, knowledge ownership also relates to the degree that an individual invests energy, time, effort, and attention in the knowledge (Csikszentmihalyi and Rochberg-Halton, 1981).

Commitment is a second aspect of knowledge internalization. Individuals develop knowledge commitment to the extent that they see the value of the knowledge, develop competence in using the knowledge (Leonard-Barton, 1995), maintain a working relationship or interaction with the knowledge, and are willing to put in extra effort to work with the knowledge (Mowday et al., 1979). The third aspect of knowledge internalization is satisfaction. Recipient satisfaction with knowledge is important because it can reduce the recipient's stress and resistance levels in adapting and using the knowledge (Leonard-Barton and Deschamps, 1988) as well as reduce the likelihood of the not-invented-here syndrome occurring (Katz and Allen, 1982). Only when a recipient *internalizes* knowledge can it be sufficiently understood and adapted by the recipient to allow for its effective re-creation and, ultimately, its use. Degree of knowledge internalization serves as the dependent variable in this study.

3. Independent variables

3.1. Knowledge context

As indicated in Fig. 1, nine factors (with positive/negative signs) affecting knowledge transfer are grouped within four broader contexts. The first context, the "knowledge context", includes the transferred knowledge's embeddedness and articulability. The basic argument here is that knowledge transfer success requires that both parties to a knowledge transfer develop an understanding of where the desired knowledge resides within the source, and that they both participate in the processes by which the knowledge is made accessible (Dixon, 1994). Lacking an understanding of where the knowledge resides within the source, the recipient may omit collection of a key knowledge component. Moreover, both R&D units' involvement in the articulation process is important because it (a) supports the recipient's later ownership of and commitment to the knowledge, (b) provides a bridge between less organizationally internalized parties, and (c) enhances the relationship (reduces any relationship distance) between the parties.

3.1.1. Knowledge embeddedness

Embeddedness is a recognized characteristic of knowledge. The issue is how many knowledge elements and related sub-networks will need to be transferred, absorbed, adapted and adopted by the recipient, and/or how many other recipients will be required to do so to allow the knowledge to be applied by the recipient. According to Argote and Ingram (2000), knowledge can be embedded in people, tools, and routines, as well as in related subnetworks among these elements (see Fig. 1). Prahalad (1993), for example, argues that companies have been unable to replicate Sony's miniaturization knowledge because this knowledge is, at least to some degree, related to, and embedded in, its specific sites, physical assets, dedicated assets, human assets, and organizational routines.

The research on knowledge embedded in individuals has shown that, whether tacit or explicit, such knowledge can be transferred by transferring individuals (Allen, 1977; Berry and Broadbent, 1984, 1987; Starbuck, 1992). Recent empirical work with respect to the mobility of engineers and their transfers of general principles and patent-embedded knowledge supported these views (Almeida and Kogut, 1999). Similarly, it was found that when there were no personnel transfers accompanying knowledge transfers, recipients often failed to learn who had expertise with different tools and routines (Moreland et al., 1996).

Knowledge can also be embedded in products (or tools). Research on the transfer of such knowledge is quite extensive, and covers both intra-firm transfers (e.g. Davidson, 1980; Mansfield et al., 1979; Teece, 1976, 1977; Zander, 1991), and inter-firm transfers (e.g. Mowery et al., 1996; Bresman et al., 1999). This literature tells us that knowledge that is in a more fluid than specific stage of its life cycle can be much harder to transfer, as identification of the appropriate knowledge elements to be shared is difficult (Abernathy and Utterback, 1978; Utterback, 1994). Nonetheless, product- or technology-embedded knowledge has been found to transfer between units more readily than knowledge embedded in other organizational elements (Zander and Kogut, 1995; Galbraith, 1990).

Knowledge can also be embedded in organizational routines and best practices (Levitt and March, 1988; Szulanski, 1996). According to Kostova (1999, p. 310), since organizational

routines may be meaning, value, and knowledge based, "the success of their transfer is determined by the transferability of meaning and value, in addition to the transferability of knowledge. Thus, the transfer of the '15 percent' practice to a foreign subsidiary of 3 M would require transferring not only the written rules explaining the practice but a meaning similar to the one that the practice has acquired for the employees at the parent company". Since routines are implicitly embedded with underlying meaning structures, this makes their transfer more difficult (Gersick and Hackman, 1990).

Finally, knowledge can also be embedded in multiple elements and subnetworks. As Teece (2000, p. 36) noted, "such knowledge cannot be moved into an organization without the transfer of clusters of individuals with established patterns of working together". Stasser et al. (1995) found that group performance increased when everyone in a group was informed of each other member's expertise. That is, when group members were informed about who knows what (the people–people network), the group's performance increased (Wegner, 1987). Moreland et al. (1996) research confirmed that group training about who knows what produces better group performance, and disruptions to a group's knowledge about who knows what (through the reassignment or turnover of people) hurts group performance.

Consistent with this research, a more complete knowledge transfer process, therefore, must incorporate an understanding that multiple knowledge reservoirs and associated subnetworks may also need to be transferred to achieve maximum transfer success, and the degree of overall knowledge embeddedness can affect such transfers. This is exactly why knowledge transfer in many NPD projects is particularly difficult; since NPD is a continuous process, knowledge used in many projects is work-in-progress. Thus, much NPD knowledge is both fluid and embedded in unspecified people, tools, and routines that define the setting in which knowledge originates. The transfer of more highly embedded knowledge, therefore, is expected to be more difficult than the transfer of less embedded knowledge.

Hypothesis 1. Transfer success decreases as knowledge embeddedness increases.

3.1.2. Knowledge articulability

Knowledge transfer success is also affected by its articulability, or the extent to which knowledge can be verbalized, written, drawn or otherwise articulated (Bresman et al., 1999). As Polanyi (1966b) noted, individuals know more than they can explain, since individuals possess tacit knowledge that is non-verbalized, intuitive, and unarticulated. Tacit knowledge is hard to communicate and is deeply rooted in action, involvement and commitment within a specific context; it is "a continuous activity of knowing" (Nonaka, 1994, p. 16); it is "the way things are done around here" (Spender, 1996, p. 54).

Research has shown that articulable knowledge is more easily transferable than less-articulable knowledge. Lippman and Rumelt (1982) argued that the replication of knowledge (in the form of a capability) is more difficult to the extent that there is ambiguity about what factors, skills, or in the language of this study, what knowledge elements and subnetworks, interactively define the function of interest. The greater the causal ambiguity, the more difficult it is to identify the related knowledge elements and subnetworks supporting the functional activity. Causal ambiguity, therefore, is often singled out as an important factor affecting knowledge transfer (Spender, 1996; Nonaka, 1994; Grant, 1996). In a study of best practices transfers (i.e. routines transfers), Szulanski (1996) found causal ambiguity

to be an important barrier to knowledge transfer. Similarly, in a study of the determinants of ambiguity, Simonin (1999) found that tacitness is positively and significantly related to ambiguity. With respect to articulability, Zander (1991) found that the nature of the knowledge being transferred, its tacitness versus its articulateness, has an important impact on the ease of transfer. Similarly, Szulanski (1996) found that this same dimension of tacitness versus articulateness was more explanatory than other factors of the difficulty of a given knowledge transfer process. In addition, Zander and Kogut (1995) found that product-based knowledge, that is codifiable, and that is explicit transfers between units more readily than less articulable knowledge. Moreover, given that "poorly articulated knowledge is difficult to teach and learn", such knowledge can be more difficult to transfer within the firm (Hakanson and Nobel, 1998, p. 13).

Hypothesis 2. Transfer success increases as the articulability of the knowledge increases.

3.2. Relational context

The NPD literature suggests that there are significant barriers to knowledge transfer across-functional, geographical, and organizational levels (Dougherty and Hardy, 1996). In this section, we deal with the variables that define the relational context of the transfer. The first variable, organizational distance, measures the degree of organizational integration between the R&D units that are parties to a transfer. Three additional relational factors of interest in this study are physical distance, knowledge distance, and norm distance. Each is defined following the discussion of organizational distance.

3.2.1. Organizational distance

Organizational distance is based on the organizing mode through which the source and recipient transfer knowledge. Organizational governance modes included in this study are intra-firm relationships, strategic alliances, and acquisitions. With respect to the impact of certain governance forms on knowledge transfer, research has found that parties that transfer knowledge from related parties, such as in franchises (Darr et al., 1995), chains (Baum and Ingram, 1998), federations (Ingram and Simons, 1997), strategic alliances (Powell et al., 1996), and networks (Uzzi, 1996), are able to transfer knowledge more effectively than from outsiders. For example, empirical studies have found that more tacit knowledge flowed across firms within a network than across independent firms (Uzzi, 1996) and that participation in regional institutions enhanced firm performance (McEvily and Zaheer, 1998).

The logic supporting the importance of organizational governance mode relates to the fact that the organizational governance mode "nominally serves to shape (a) the flow of assets, (b) the depth and breadth of interaction between the two [units], and (c) the incentives for collaboration" (Baughn et al., 1997, p. 109). Others have reached the same conclusions with respect to differences in administrative controls affecting knowledge flows (Gupta and Govindarajan, 1991b), and related coordinating activities (Geringer and Hebert, 1989; Killing, 1982). Fundamentally, the greater denseness of social ties available to network members (Tushman, 1977) facilitates all of these benefits, as such social ties allow for better opportunities to share knowledge and experiences, develop trust, and cooperate

(Granovetter, 1985). As Argote (1999, p. 168) noted, "competition is usually minimized" among the firms within franchises, chains, and networks, and "the organizations generally trust each other to a greater degree than those not [so] embedded".

Consistent with this line of reasoning, it seems reasonable that the strength of social ties, free-flow of communication, consistency in administrative controls, and levels of trust between the source and recipient will be greater to the degree that the units are organizationally internalized (i.e. the smaller the organizational distance). Organizational internalization, moreover, is greatest within an organization (intra-firm mode), less so within recently internalized units (acquisition mode), and the least within inter-firm knowledge transfers (alliance mode).

Hypothesis 3. Transfer success decreases as organizational distance between source and recipient increases.

3.2.2. Physical distance

Physical distance refers to the difficulty, time requirement, and expense of communicating and getting together face-to-face. Studies investigating the impact of physical distance have found that patent citations frequently cluster in certain regions (Almeida, 1996). The larger the distances between the parties, the slower and less the technology transfer (Galbraith, 1990; Lester and McCabe, 1993). In each of these cases, the underlying logic developed was that the parties draw on social capital embedded within the regional or group relationships to facilitate the development of good communication between the parties, and that such social capital is harder to develop among physically distant parties (Allen, 1977; Cohendet et al., 1999). In further support of these findings, others have found that face-to-face meetings are superior to other meeting or transfer formats in the transfer of strategically important matters (Athanassiou and Nigh, 2000), computer simulation technology (Dutton and Starbuck, 1979), and engineering designs (Davenport and Prusak, 1998). In NPD research, it has been found that parties need to go through iterations of doing, learning, and doing some more in order to develop R&D capability (Wheelwright and Clark, 1992). Such intense interactions demand a close proximity. Finally, there is also much anecdotal evidence of the importance of physical distance, as it has been widely reported that SGS-Thomson in Texas commonly extends Texas Instrument patents, as does Siemens in New Jersey with respect to nearby Bell Labs and AT&T (Almeida, 1996).

Hypothesis 4. Transfer success decreases as physical distance between source and recipient increases.

3.2.3. Knowledge distance

Knowledge distance is the degree to which the source and recipient possess similar knowledge. For R&D knowledge transfer, a particular difficulty is that the R&D contexts of the source and the recipient can be quite different. The R&D output of the source is often the R&D input of the recipient, and there may hardly be any other overlap between the R&D activities of the two parties. If so, whether it is a cross-functional or a cross-organizational transfer, learning would be more problematic. In the NPD literature, it

is recognized that shared interpretation of knowledge is essential for collaboration in R&D activities (Dougherty, 1992).

It has been found that, for organizational learning to take place, the knowledge distance or 'gap' between two parties cannot be too great (Hamel, 1991) The reason is that too many learning steps will be required if the knowledge gap (or distance) is significant. In this sense, it is believed that knowledge redundancy and overlapping areas of expertise facilitate knowledge transfer (Nonaka and Takeuchi, 1995). As Hamel (1991, p. 97) put it, "if the skill gap between partners is too great, learning becomes almost impossible", as the recipient may be unable "to identify, if not retrace, the intermediate learning 'steps' between its present competence level and that of its partner". Dinur et al. (1998) also argued that some alignment in terms of two parties' knowledge and other factors is necessary for knowledge transfer.

In addition, the literature on inter-firm learning has emphasized the concept of "absorptive capacity", which means that firms differ in terms of their ability to learn (Cohen and Levinthal, 1990; Lyles and Salk, 1996; Szulanski, 1996). Recently, it was further argued that this capacity might be "relative" in nature (Lane and Lubatkin, 1998). That is, a firm's ability to learn is related to the fit between the knowledge of the source and of the recipient. It can be argued that firms with significant common knowledge (Dixon, 2000) (or low knowledge distance) would have a high "relative absorptive capacity", suggesting the following hypothesis.

Hypothesis 5a. Transfer success decreases as knowledge distance between source and recipient increases.

At the same time, scholars have also argued that too small a knowledge gap may burden the recipient with unlearning old knowledge prior to learning any new knowledge (Burgleman, 1983; Hedberg, 1981; Nystrom and Starbuck, 1984). In addition, parties may become less satisfied with their transfer activities if there is not much knowledge to be transferred due to too small a knowledge gap. Indeed, a premise for effective learning is a certain degree of knowledge gap between the parties. Thus, there may be a curvilinear relationship between knowledge distance and transfer success. This logic is tested using the following hypothesis.

Hypothesis 5b. The relationship between transfer success and knowledge distance between the source and the recipient is curvilinear (an inverted U-shape).

3.2.4. Norm distance

Norm distance is the degree to which knowledge transfer parties share the same organizational culture and value systems. Early research on technology transfer has shown that differences in work values and organizational cultures can significantly impair knowledge transfers (Allen, 1977; Tushman, 1977). The reason is that similar cultures and value systems allow for a smooth working relationship between the knowledge transfer parties. After all, culture and shared norms define what is acceptable and unacceptable in a work place (O'Reilly and Chatman, 1996). Common norms not only provide predictability and understanding between the parties, but also ensure that a common approach will be adopted in the transfer process.

As such, knowledge is embedded in cultures and routines. R&D team members draw on their experience with prior routines when faced with new knowledge (Louis and Sutton, 1991). Indeed, the ability to access previously created knowledge is critical for the success of NPD efforts (Garud and Nayyar, 1994). To the degree that these prior routines and scripts are consistent with those of the source, their interactions will occur in a well-coordinated fashion (Bettenhausen and Murnighan, 1985; Gersick and Hackman, 1990). On the contrary, significant disagreements or miscues can indicate that the new knowledge is not being accepted or internalized (Hackman, 1969).

Hypothesis 6. Transfer success decreases as norm distance between source and recipient increases.

3.3. Recipient context

In addition to the four relational factors, there are also factors related to the recipient's receptiveness to learning new knowledge and to the extent of effort put forward to undertake transfer activities that can affect transfer success. Research has identified several aspects of the recipient context as important to knowledge transfer; key among these are the priority of the project for the recipient and its predisposition for learning. These two factors are included in the 'recipient context' in the research model.

3.3.1. Project priority

Since projects with different priorities may receive different degrees of attention and/or resources, project priority was included as a recipient-context variable. Consistent with prior research, which used variables such as collaborative experience (Simonin, 1999), relationship duration (Simonin, 1999), business context (Yeung et al., 1999), absorptive capacity (Lane and Lubatkin, 1998), and firm size (Bresman et al., 1999), what seems to be important is to gauge the relative importance of the project to the R&D unit. As Nelson and Winter (1982, p. 78) noted, "when circumstances place a great premium on effective articulation, remarkable things can sometimes be accomplished. For example, it has been established in occasional emergency situations that it is not impossible to convey by radioed verbal commands enough information on how to fly a small plane so that a person who lacks a pilot's skills can bring the plane in for landing". Other researchers have identified the conceptually similar concepts of learning intent (Baughn et al., 1997; Hamel, 1991) and motivation (Szulanski, 1996) of the recipient as important factors in transfer success. The idea is that, when a recipient sees the knowledge transfer project as high priority, it will have greater motivation to support the transfer than if the project is seen as less significant.

Hypothesis 7. Transfer success increases as project priority increases.

3.3.2. Learning culture

The need for a culture of learning in an organization to facilitate organizational learning in general, and knowledge transfer specifically, has been emphasized by many researchers (Aubrey and Cohen, 1995; Fiol and Lyles, 1985; Huber, 1991). In a firm with

a learning generalization organizational culture, for example, there is sufficient slack to allow employees to obtain what Davenport and Prusak (1998) term high viscosity in the knowledge being transferred. The idea is that knowledge transfer has two dimensions. Knowledge velocity refers to the speed with which knowledge is transferred. Knowledge viscosity refers to the richness of the knowledge transferred. The question is to what extent the knowledge being transferred gets pared down. In an organization that fosters delegating responsibility, tolerating creative mistakes, and providing slack time to work on new ideas, knowledge viscosity in transfer is likely to be much higher (Davenport and Prusak, 1998).

In some organizations, the not-invented-here syndrome can prevent recipients from accepting outside knowledge (Hayes and Clark, 1985; Katz and Allen, 1982), especially if doing so requires its members to abandon knowledge and abilities that have been important to them personally (Leonard-Barton, 1995). Where the pathology of the not-invented-here syndrome takes hold, many dysfunctions with respect to a recipient assimilating the knowledge can also occur (Szulanski, 1996).

Moreover, even when knowledge is transferred to a willing recipient, the transfer will only be effective when the knowledge is retained (Glaser et al., 1983; Druckman and Bjork, 1991). Given the evidence from research on innovations (Rogers, 1983) and planned organizational change (Glaser et al., 1983), retention cannot be taken for granted. Moreover, even if retained, the knowledge may not be nurtured and further developed if learning is not considered important, because the slack required to enable people to think and discuss, and for learning groups to emerge, may be sacrificed in the name of efficiency (Stewart, 1996). Since it is some set of transfer activities, mechanisms, or processes that forms the basis for knowledge transfer to occur, it is these same activities, mechanisms, or processes that form the organization's retentive and nurturing capacity. In other words, recipients with an extensive set of routines and learning competencies designed to retain and nurture transferred knowledge—with a learning culture—may achieve greater knowledge transfer success.

Hypothesis 8. Transfer success increases as recipient's degree of learning culture increases.

3.4. Activity context: transfer mechanisms

The fourth context in the research model is the 'activity context'. The knowledge transfer literature identifies three interdependent types of knowledge transfer activities, including those focused on assessing the form and embeddedness of the knowledge; those focused on establishing and managing an administrative structure through which differences and issues between the parties can be accommodated and reduced, and those focused on transferring the knowledge. Each has been shown to be important in affecting knowledge transfer outcomes. These activities are interdependent in that knowledge assessment and administrative requirements will change as differences and issues become apparent between the parties, all while efforts to transfer the desired knowledge are being implemented. Each type of activity is also important. For example, while a company may put in place appropriate administrative structures and undertake a number of managerial initiatives designed to overcome any differences between the organizations, a lack of an assessment as to the embeddedness of the

knowledge to-be-transferred can easily result in a less than successful outcome (Davenport and Prusak, 1998).

What the literature points to is that successful knowledge transfer outcomes require attention to many types of activities, suggesting, therefore, that the greater the involvement of the parties to a knowledge transfer through various forms of activities, the greater the likelihood that the recipient will be able to internalize the knowledge.[2] To test this logic, the following hypothesis is developed.

Hypothesis 9. Transfer success increases as the number of transfer activities increases.

4. Methods

4.1. Questionnaire survey

This research used the Total Design Method mail survey questionnaire approach (Dillman, 1978) to sample R&D executives at US high technology companies with sales greater than US$ 10 million and with a work force of more than 100 employees. A sample of 1000 cases was randomly drawn from an *R&D Magazine* database. This target population was selected because the transfer of technology-embedded knowledge between R&D units has been reported to be concentrated in similar company sectors. Technology-embedded transfers are focused on because member-, routine-, and network-based knowledge are known to frequently accompany the transfer of technology-embedded knowledge, thereby allowing the study to be comprehensive of the different forms of knowledge-embeddedness identified in the literature (Galbraith, 1990; Rothwell, 1978; Argote and Ingram, 2000; Teece, 2000). Moreover, given this study's focus on inter- and intra-firm knowledge transfers, it was important to target a population of firms that have participated in R&D-related strategic alliances and acquisitions as well as inter-organizational R&D knowledge transfers. In order to gain a reasonable proportion of respondents across-organizational governance modes, following Simonin (1999), and consistent with other international research (Aulakh et al., 1996; Hladik, 1985; Morris and Hergert, 1987), this population is targeted to maximize the potential of surveying firms that have participated in alliances and acquisitions. Lastly, consistent with other knowledge transfer research (Bresman et al., 1999), R&D managers are targeted in order to ensure a focus on cases where knowledge transfer is important. Knowledge transfers are an integral aspect of the R&D function. The strategic nature of the survey's content with its focus on knowledge transfers, and on a broad set of contextual variables affecting knowledge transfer, necessitates the participation of R&D executives whose understanding and field of action encompass an overall unit (Parkhe, 1993). The questionnaire, pre-tested on a knowledgeable group of professional R&D managers and

[2] While beyond the scope of this current study, a more fine-grained way of looking at knowledge transfer mechanisms is related to the degree to which a mechanism supports the exchange and interaction of, and/or dialogue among individuals from the source and the recipient, versus the degree to which they do not. Consistent with organizational learning theory, the more advanced transfer activities—those that support 'indwelling' (Polanyi, 1966a)—would be expected to be associated with higher levels of transfer success than the more basic ones, although research has not fully supported this logic (see Cummings, 2002).

academics, prompted the respondents to focus on a past but recent (formed less than 5 years ago) transfer project with which they were familiar.

Sixty-nine usable responses collected over a 6-week period in early 2001 were obtained from a final sample of 861 (1000 minus non-deliverables), for a response rate of 8%. Following Podsakoff and Organ's (1986) approach, there was no indication of common method bias based Harmon's one-factor test. The respondents were predominantly male (95%), with an average age of 49 and a firm tenure of 13 years; 84% of the respondents were R&D Managers, General Managers, or Directors. A sufficient physical distance separated approximately 50% of the firms that overnight travel was required for site visits and other face-to-face meetings to take place, and roughly one quarter resided in different nations, thereby providing the needed variation to test the physical distance hypotheses. Moreover, while not proportional, there was also sufficient distribution among the three governance modes to perform tests of the organizational distance hypothesis, and 15 different industries were represented.

4.2. Construct measurement

To insure the reliability and validity of the measurement system, wherever appropriate multi-item scales are developed for each construct in the model, most using validated Likert-type interval scales ranging from 'to very little extent' to 'to very large extent'. Bresman et al. (1999, p. 449) noted that they spent a great deal of time with their R&D reference group to formulate the term *technological know-how* to capture the forms of knowledge that they were interested in, the phrase *active transfer* to be sure that the respondents focused on transfers rather than diffusions of knowledge, and the period of 5 years to allow fluctuations over time to be smoothed out. Similar terminology and the same time-frame were adopted wherever possible in this study.

The fundamental theme of the research model in this study is that there are a number of factors that can make the accessibility of tacit and/or deeply-embedded knowledge difficult, and thereby decrease the recipient's satisfaction with, commitment to and ownership of the knowledge (Kostova, 1999). As the dependent variable in this study, *transfer success* is measured using a 22-item scale that includes seven items adapted from Szulanski (1996) to measure satisfaction related to cost, schedule and performance, nine knowledge commitment related items from Pierce et al. (2001) and six knowledge ownership related items from Mowday et al. (1979), to provide a robust measure of transfer success (alpha = 0.76).

With respect to the nine independent variables, two constructs were measured within the knowledge context. *Embeddedness* was measured on four levels, including member-embeddedness, technology-embeddedness, routines-embeddedness, drawn from Mowday et al. (1979), and overall embeddedness drawn from Baughn et al. (1997). The four reverse-coded items asked respondents how easy it was to identify source personnel who could help them reconfigure the knowledge, or learn the tools, equipment and technologies related to the knowledge; how easy it was to identify the appropriate tools to use to perform necessary activities, tasks and procedures; and how easy it was to locate and extract the information needed to understand the knowledge (alpha = 0.74). *Articulability* was measured using a five-item scale drawn from Hakanson and Nobel (1998), Bresman

et al. (1999), and Zander (1991). The items asked respondents to what extent new R&D personnel could easily learn the knowledge necessary to do their jobs by studying, talking with, or apprenticing under R&D personnel, and how quick and easy it is and how much experience it takes for R&D personnel to become capable in using the knowledge (alpha = 0.61).

Four constructs were measured within the relational context. With respect to *organizational distance*, this study examined knowledge transfers across three organizational governance modes, including intra-firm, acquisitions, and alliances. In order to test the hypothesis that the degree of distance between the source and recipient affects transfer success, a scheme drawn from the strategic alliance (Madhok, 1997) and acculturation literatures (Berry, 1983) was used to categorize organizational distance (the inverse of internalization) as greater within organizations (intra-firm mode) than within recently internalized units (acquisition mode), and least within non-internalized units (alliance mode), with subcategories also provided within each based on the duration of the mode for the former two, and equity versus non-equity for the alliance mode. *Physical distance* has been operationalized in the literature primarily in terms of geographic regions (Almeida, 1996) and geographic proximity (Galbraith, 1990; Lester and McCabe, 1993). In this study, physical distance was measured using the number of miles between the parties. Two other direct measures of physical distance, including average travel costs and average per diem costs for lodging and meals, were also tested, but yielded substantially the same results when substituted for miles. *Knowledge distance* was the third construct measured within the relational context. The concept of a knowledge gap has been discussed by a number of researchers with respect to its potential impact on knowledge transfer (Hamel, 1991; Lane and Lubatkin, 1998; Dinur et al., 1998; Nonaka and Takeuchi, 1995). Lane and Lubatkin (1998) measured the overlap between source and recipient knowledge bases by counting the number of research communities in which both partners had published during a defined period of time using a bibliometric database from the Center for Research Planning. Given the cross-industry nature of this study, such a measurement system would not be practical. Rather, four perceptual questions were used (and reverse coded when applicable), where respondents were asked to assess the extent to which the source and recipient had the knowledge bases necessary to easily understand how to work with the knowledge; and the extent to which the overlap of knowledge bases was cause for difficulties in communications or would have allowed the parties to publish substantially the same scientific articles (alpha = 0.63). Lastly, with respect to *norm distance*, a two-item scale was developed to assess the degree to which the parties had dissimilar prior routines and scripts. Following Gersick and Hackman (1990), Hackman (1969), and Louis and Sutton (1991), these questions, which were reverse coded, focused on the extent to which the interactions between the units were immediately well coordinated and demonstrated a shared understanding of the project (alpha = 0.83).

The third broad context examined in this study was the recipient context, which included the variables project priority and learning culture. With respect to *learning culture*, Yeung et al. (1999, p. 160) instrument was used to "assess the extent to which ideas are generalized in [a] company". Four items were adapted from this instrument to assess the extent to which the recipient units supported overreach failures, environmental scanning, a future rather than a past focus, and a belief that knowledge is more important than job title

(alpha = 0.73). For *project priority*, two questions were asked of respondents, including what percentage of the unit's total man-hours were devoted to the project, and what the project's priority level was on a five-point scale. These responses were then normalized (alpha = 0.76).

The final context examined in this study was the activity context. In order to measure the *transfer activities* for each of eleven transfer mechanisms identified in the literature, respondents were asked to indicate how frequently each was used and approximately how many people participated on average each use. A question related to the duration of the project was included in this same section to help the respondent delimit an appropriate time-frame within which to assess usage patterns. For each transfer mechanism, the number of times used and the number of people who participated were multiplied to calculate an index of usage. The specific items used, and their means and standard deviations, are reported in the Appendix A.

5. Results

Table 1 reports the zero-order, bi-variate correlations between all the variables. While none of these correlations are considered to be high (above 0.7), two of the independent variables were moderately and significantly negatively correlated with the dependent variable, transfer success, as expected (knowledge embeddedness: $r = -0.482$ and $P < 0.001$; and norm distance: $r = -0.438$ and $P < 0.001$). With respect to the other expected bi-variate relationships between the independent variables and the dependent variable, three other variables were significant at $P < 0.01$, including articulability ($r = -0.329$ and $P = 0.003$), knowledge distance ($r = -0.315$ and $P = 0.004$), and learning culture ($r = -0.319$ and $P = 0.004$); and one was significant at $P < 0.1$, namely, transfer activities ($r = 0.269$ and $P = 0.013$). Since all of the hypothesized relationships are directional, all variables were tested using one-tailed significance tests. With the exception of articulability, all of the significant relationships were consistent with their respective directional hypotheses. Several multicollinearity tests were conducted to ensure the independence of the independent variables.

5.1. Hypotheses

Table 2 reports the results of the hierarchical multiple regression models that were used to test the hypotheses. In the first step, seven variables related to the knowledge, relational and recipient contexts were entered to allow examination of the effects of the organizational distance and transfer activities independent variables after the effects of the other variables were controlled. In this first step (model 1), since there was no a priori reason to enter any of these variables in a specific hierarchical order, all seven of these independent variables were entered together in order to evaluate their main effects. Two of the variables, knowledge embeddedness and norm distance, were significant at $P < 0.01$, and knowledge articulability and knowledge distance were each significant at $P < 0.05$. These seven independent variables resulted in an $R^2 = 0.467$ ($\Delta F = 7.648$, $P < 0.001$). All together, the main effects accounted for approximately 40% of the variance in transfer success on an adjusted basis

Table 1
Zero-order correlation coefficients ($n = 69$)

S. no.	Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9
1	Articulability	10.14	2.58	1.0								
2	Embeddedness	8.80	2.41	0.163^{+}	1.0							
3	Physical distance	1433	2303	−0.113	−0.025	1.0						
4	Knowledge distance	8.59	2.60	0.040	0.229*	0.116	1.0					
5	Norm distance	5.22	1.71	0.076	0.225*	−0.110	−0.003	1.0				
6	Learning culture	10.58	2.71	−0.210*	−0.127	0.123	−0.181	−0.265*	1.0			
7	Project priority	3.96	1.09	0.002	0.118	−0.164	−0.126	−0.066	0.327**	1.0		
8	Organizational distance	4.99	2.93	0.039	0.022	−0.221*	0.061	0.106	0.010	0.120	1.0	
9	Transfer activities	2.52	1.13	0.069	−0.078	0.090	−0.097	−0.021	−0.066	0.126	−0.211*	1.0
10	Transfer success	57.58	9.50	−0.329**	−0.482***	0.081	−0.315**	−0.438***	0.319**	0.056	0.007	0.269*

* $P < 0.05$ (one-tailed significance level).
** $P < 0.01$ (one-tailed significance level).
*** $P < 0.001$ (one-tailed significance level).
$^{+}$ $P < 0.1$ (one-tailed significance level).

Table 2
Results of hierarchical regression analysis ($n = 69$)

Variable	Model			Model 3	
	1	2	3	Part correlation	(Part correlation)^2 (%)
Step 1					
Knowledge context					
Articulability	−0.221*	−0.222*	−0.244**	−0.234	5.48
Embeddedness	−0.312**	−0.309**	−0.277**	−0.253	6.40
Relational context					
Physical distance	0.029	0.046	0.014	0.013	0.02
Knowledge distance	−0.219*	−0.228*	−0.207*	−0.193	3.73
Norm distance	−0.321**	−0.330**	−0.331***	−0.308	9.49
Recipient context					
Learning culture	0.099	0.095	0.141	0.121	1.46
Project priority	0.018	0.010	−0.054	−0.047	0.22
Step 2					
Organizational distance		0.080	0.138	0.130	1.69
Step 3					
Transfer activities			0.282**	0.265	7.02
ΔR^2	0.467	0.006	0.070		
ΔF	7.648***	0.667	9.065**		
R^2	0.467	0.473	0.543		
Adjusted R^2	0.406	0.403	0.474		

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

(*adjusted* $R^2 = 0.406$). In the second step (model 2), adding the organizational distance variable did not achieve significance ($\Delta R^2 = 0.006$, $\Delta F = 0.667$, ns), and the variable was found to be not significant. In the third step (model 3), adding the transfer activities variable resulted in an $R^2 = 0.543$ ($\Delta F = 9.065$, $P < 0.01$). All together, the main effects accounted for approximately 47% of the variance in transfer success on an adjusted basis (*adjusted* $R^2 = 0.474$). Of the nine hypothesized main-effect relationships tested in model 3, five of these hypotheses were found statistically significant. Specifically, norm distance was significant at $P < 0.001$; knowledge embeddedness, knowledge articulability, and transfer activities were significant at $P < 0.01$; and knowledge distance was significant at $P < 0.05$.

The result regarding Hypothesis 5 needs to be noted. As opposed to Hypothesis 5a, which predicts a negative linear relationship between knowledge distance and transfer success, Hypothesis 5b predicts a curvilinear (inverted U-shaped) relationship between these variables. To test for such a curvilinear relationship, we included both knowledge distance and knowledge distance squared in a regression (not reported here for simplicity). Neither variable was significant. In addition, since knowledge distance itself was negative and significant in the regression as reported, we conclude that, supporting Hypothesis 5a, there is a negative linear, rather than curvilinear, relationship between knowledge distance and transfer success.

5.2. Relative influence of each variable

Following Hair et al. (1996), assessment of the relative importance of each variable is accomplished by evaluation of the standardized regression coefficients, which provide an indication of the relative importance of each independent variable with respect to each other. Since there is little multicollinearity, these betas can be used to make such an assessment. Table 2 also presents the part correlation coefficients, and the square of part correlation coefficients for each variable. Among the variables significant at the 0.01 and 0.05 levels, each are relatively of the same importance in the regression variate, with betas of −0.234 for knowledge articulability, −0.253 for embeddedness, −0.193 for knowledge distance, −0.308 for norm distance, and 0.265 for transfer activities. With respect to each variable's unique predictive effect once all others are controlled, the squared part correlation coefficients indicate that knowledge articulability explains about 5.5%, embeddedness 6.4%, knowledge distance 3.7%, norm distance 9.5%, and transfer activities 7.0% of the variation of the dependent variable. These results indicate that the knowledge context accounts for roughly 12%, the relational context 13%, and the transfer activities context 7% of the transfer success variation in this particular sample.

6. Discussion and conclusions

6.1. Limitations of the study

The results of this study are of course subject to a number of limitations. First, the research model in this study integrates research across three governance modes, thereby providing a relatively simplified perspective of the literature on knowledge transfer. As Casson (1981, p. 15) states, the complexities inherent in seeking to develop conceptual integrations "mean that the theorist must tread a careful path between oversimplification on the one hand, and a preoccupation with minor detail on the other. Some theorists are over-ambitious, and range too widely to do justice to any one aspect of their subject". While every attempt was made to avoid such an oversimplification by including only constructs in evidence in each of the governance-mode specific literatures, the comprehensiveness of the model necessarily simplifies reality.

Moreover, the study's small sample size, although consistent with many studies of knowledge transfer (e.g. Zander and Kogut, 1995; Tyler and Steensma, 1998; Bresman et al., 1999; Lane and Lubatkin, 1998; Szulanski, 1996), limits the finding's statistical power. Future research on the factors affecting knowledge transfer could benefit from following Steensma and Corley's (2000) approach in which they used an announcement database for sample selection, and the data contained therein for purposes of personalizing the mailings and defining the knowledge transfer project for the respondents.

6.2. Findings and implications

Notwithstanding its limitations, the study obtained findings that are consistent with extant organizational learning theories and several prior empirical studies. Thus, this research

contributes to the literature by providing empirical support for several theories and previously defined and/or tested constructs. For example, the articulability and embeddedness constructs measured in this study suggest the importance of knowledge context (Dixon, 2000; Kostova, 1999). Relational variables tested in this study support the idea that contextual dimensions need to be aligned to facilitate knowledge transfer (Dinur et al., 1998). In addition, the variable knowledge distance confirms Hamel's (1991) notion of the receptivity of the recipient based on its knowledge gap with the source. Moreover, the study also examined the influence of the degree of transfer activities undertaken on transfer success. It found evidence that the degree of interaction between new product development (NPD) partners affects knowledge transfer outcomes (Almeida and Kogut, 1999; Galbraith, 1990). Importantly, rather than only examining each of these variables separately, the hierarchical regression analysis also supported assessment of the relative contributions of each variable to transfer success. The findings suggest that R&D managers should pay attention, at a minimum, to the form and embeddedness of the knowledge, any potential relationship distances between the parties, and the degree of interactions undertaken between the parties.

In particular, as in prior research, this study found that the form of the knowledge to be transferred, in terms of its articulability and its embeddedness, could play a critical role in its ultimate transferability. Unlike prior research, however, and contrary to the hypothesized relationship between articulability and transfer success, articulability proved to be *negatively* related to transfer success. In other words, knowledge that can be readily codified in manuals, diagrams, etc. is *less* likely to be internalized within the recipient than less articulated knowledge. A plausible explanation for this finding relates to the operationalization of the dependent variable in this study, and the logic of organizational learning theory. In the development of the articulability hypothesis, the extant research supporting a positive association between articulability and transfer success used measures of knowledge transfer success focused on the number of transfers that occurred and/or how difficult the transfer processes were.

In *this* study, the dependent variable refers to the degree to which the transfer resulted in knowledge internalization—ownership of, commitment to, and satisfaction with the knowledge. Nonaka (1994), Dixon (1994) and Yeung et al. (1999) tell us that organizational learning requires, among other things, the reconstruction and adaptation of the transferred knowledge at the receiving end (Kogut and Zander, 1992). This is because the incompatibilities and incongruence of the knowledge may only come to light as it is put to use in the recipient (von Hippel and Tyre, 1995; Argote, 1982). This is also because knowledge codified by a source may be incompatible with a recipient's cultural beliefs and idiosyncratic ways of conducting business. As a result, such knowledge could lack legitimacy in the recipient's context, and the recipient may be less motivated to take ownership of, and become committed to this knowledge.

Nonetheless, there still seems to be two competing views about how much articulation is appropriate. The fact remains that since codified knowledge is easier to transfer, as long as appropriate de-contextualization processes occur with respect to the knowledge, its transfer is likely to be more successful than one including less articulated knowledge. Such a conclusion is consistent with Brannen et al. (1998) findings with respect to factory-to-factory transfers of knowledge. They found that knowledge is so context bound

that it must be de-contextualized at the source before being transferred and ultimately re-contextualized by the recipient as it seeks to make meaning of the knowledge within its environment. On the other hand, too much reliance upon codification might limit a knowledge package's internalization, as a seemingly complete codification could ignore the reality that tacit elements still exist (Polanyi, 1966b) or simply be seen as lacking legitimacy.

With respect to knowledge embeddedness, which refers to the extent to which knowledge is held within an organization's routines, systems, and social networks, this study found that knowledge that is more deeply embedded within these repositories is more difficult to transfer than less deeply embedded knowledge. From a practical standpoint, this suggests that R&D managers should develop a knowledge evaluation scheme or internal knowledge scanning process (Garud and Nayyar, 1994) through which they can assess the degree of embeddedness of certain knowledge within the organization, and then use this information to guide their development of both pre-transfer knowledge preparation processes and overall knowledge transfer plans.

Another key aspect of a transfer that needs to be understood is the relationship between the source and recipient R&D units. This study found that two relationship-related variables are significantly associated with transfer success, including norm distance and knowledge distance. Norm distance refers to the extent to which the parties share similar understandings and ideas about the knowledge transfer project. The idea is that it is easier to transfer knowledge between people who can readily interact in a well-coordinated fashion, and the greater the norm distance, the harder this will be (Gersick and Hackman, 1990). Regarding NPD activities, this study supports the finding that a concurrent transfer mode, as opposed to a sequential mode, between base projects and new projects improves the efficiency of NPD efforts (Nobeoka, 1995). The implication is that NPD managers ought to constantly coordinate knowledge transfers between source and recipient, in order to reduce norm distance between the two units. Moreover, since NPD efforts are by definition exploratory, the concurrent mode can also help in the ongoing assessment of the knowledge's embeddedness.

The second significant relational variable, knowledge distance, refers to the degree of overlap of the knowledge bases of the source and the recipient. A curvilinear relationship between knowledge distance and transfer success was not found. A possible explanation is that recipient firms would pre-screen source partners to find situations where they have much knowledge to learn. Thus, the focus would be on whether the source has enough knowledge, not on whether the source might have too much knowledge available. As such, this study confirms that there is a negative relationship between knowledge distance and transfer success. Lacking an appropriate overlap of knowledge, it is obvious that any teacher-student relationship between the parties will be made more difficult.

Importantly, each of these findings has implications for NPD activities in which learning and knowledge transfer are critical, such as in cross-functional teams or cross-organizational efforts (Brown and Eisenhardt, 1995; Kazanjian et al., 2000; Nobeoka, 1995). For example, the results with respect to transfer activities supplements the findings that learning in complex NPD projects is enhanced by highly interactive and iterative communications by cross-functional teams (Brown and Eisenhardt, 1995) and as well as by interactions and deliberations that encourage active inquiry and participative decision making (Purser

et al., 1992). In addition, consistent with the notion that NPD is a dynamic and interactive problem-solving process (Iansiti and Clark, 1994; Teece, 1992), the results with respect to articulability suggest that R&D managers might be directed to undertake a sort of pre-transfer, knowledge-preparation process *involving both the source and recipient* to make certain that any tacit knowledge is made to be both (a) more accessible via conversion to a more articulable form, and (b) more internalizable to the intended recipient. Such a process would entail the use of multiple presentations, discussions, and dialogues about the knowledge across multiple teams within both the source and the recipient organizations. It would also involve providing opportunities for the teams to put the knowledge into action, either through role-playing or case-related activities, to allow for the type of tacit–explicit conversions (Nonaka, 1994) and reflective learning by doing (Weick, 1979) that business strategy professors use to transfer business strategy knowledge to students. With respect to norm distances, in addition, the findings suggest that, as Lovelace et al. (2001) suggested, any disagreements and task-related doubts that arise during such an articulation process ought to be openly and adequately discussed. Lastly, it also seems reasonable that the same transfer processes that could be used to support the development of shared understandings (reduced norm distances) could also help reduce any knowledge gaps between the parties.

Thus, while the objective of the embeddedness analysis would be to develop an understanding of the knowledge elements needing to be transferred, the objective of the knowledge-preparation process would be to involve both the source and recipient in the articulation of knowledge, so as to reduce the relational distances that may exist between the parties. However, simultaneous with both or either of these processes, R&D managers could also assess potential sources' and recipients' knowledge bases. Such a knowledge-gap analysis would allow the managers to assess the relative overlap of the parties' knowledge bases, so as to avoid situations where there is either too much or too little overlap, perhaps by using bibliometric analysis (Lane and Lubatkin, 1998). As Hamel (1991) suggested, too much overlap would require too much unlearning, and too little overlap would require too much teaching. With such an analysis in hand, a manager could use this information to select among the alternative sources or recipients.

One interesting finding in this study is that the separation of research on knowledge transfer by governance mode may have less importance in reality than in convention or in research ease, as organizational distance was not found to be a statistically significant factor in this study. Nonetheless, to the extent that organizational mode does matter, it seems clear that relationship building between less organizationally internalized parties could improve transfer success. In turn, this would make decision making with respect to the appropriate organizational governance mode through which to execute the knowledge transfer project considerably less complex. In other words, assuming that a reasonable knowledge preparation process can be implemented regardless of whether the knowledge transfer is to occur through an acquisition, intra-organizationally, or through an alliance, the choice of governance mode can be made for rationales other than the need to facilitate knowledge transfer.

Another interesting finding was that the physical distance variable was also not statistically significant. Given that the locational anchors for many important technologies are becoming geographically dispersed across the globe in countries from India to Finland to

Singapore to Israel, this is an important finding. This finding seems to fly in the face of research on NPD that has shown advantages to co-location in the creation and melding of technical knowledge (Allen, 1977; von Hippel, 1988), and difficulties that can come about within dispersed collaborative teams (Davenport and Prusak, 1998). On the other hand, perhaps as Cohendet et al. (1999, p. 232) suggest, the socialization that takes place between knowledge transfer parties contributes to the creation of a "common knowledge base that becomes part of the organizational memory" that helps to eliminate the spatial distances between the parties.

Noticeably, neither of the two recipient context variables (project priority and learning culture) was found to be significant. Regarding priority, one possibility is that managers have relatively low expectations regarding low priority projects. That is, managers may be more easily satisfied with regard to less important knowledge, as they focus on high priority projects. Similarly, it may be argued that firms with a high learning culture set high standards for their knowledge transfer activities. Since such firms have a history of knowledge transfer, they are likely to be more critical about their learning endeavors.

For virtual R&D teams, this research presents some interesting results. The conventional wisdom is that there are additional obstacles to knowledge transfer success in virtual teams. Since members of virtual teams may lack face-to-face meetings, the richness of knowledge tends to be lost in the transfer process (Allen, 1977). Indirectly supporting this view, we found that the use of more types and numbers of transfer activities contributed to transfer success. As such, virtual teams may have a disadvantage, as many activities require face-to-face meetings.

At the same time, we did not find physical distance to be significantly related to transfer success. While contrary to most extant theory, this finding is consistent with one recent study of virtual teams that found that they make more effective R&D continuation decisions than face-to-face teams (Schmidt et al., 2001). The reason is that asynchronous communication allows for more time for digestion and reduces the pressure for group conformity. Therefore, our finding suggests that physical distance per se may not undermine the effectiveness of virtual R&D teams. Rather, based on the positive effect of transfer activities, the key seems to be to employ various and numerous transfer techniques when facing physically distant communications, as these activities, whether conducted face-to-face or virtually, will allow the parties to enhance their understanding of the knowledge, reduce relationship distances, and provide the mechanisms through which the source's knowledge can be de- and then re-contextualized within the recipient.

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Appendix A

Items in Questionnaire		Mean	S.D.
Embeddedness	To what extent do the following statements characterize how well the transfer project proceeded? (Extent scale)		
(Alpha = 0.74) (Items = 4)	1. It was easy for the recipient to identify source personnel who could help them reconfigure and adapt this know-how.	2.20	.78
	2. It was easy for the recipient to identify source personnel who could help them learn the tools, equipment and technologies related to this know-how.	2.03	.72
	3. It was easy for the recipient to identify which tools to use to perform each activity, task and procedure.	2.27	.78
	4. It was easy for the recipient to locate and extract the information needed to understand this know-how.	2.31	.91
	Items 1-3 are based on Moreland, Argote & Krishnan (1996); Item 4 is from Baughn, et al. (1997: 108).		
Articulability	To what extent do the following statements characterize the know-how that recipient unit received? (Extent scale)		
(Alpha = 0.61) (Items = 5)	5. New R&D personnel can easily learn this know-how by studying a complete set of blueprints, documents or plans.	1.87	.86
	6. New R&D personnel can easily learn this know-how by talking to experienced personnel.	2.13	.78
	7. Educating and training new R&D personnel regarding this know-how is a quick and easy job.	1.72	.78
	8. The tasks of the unit require that personnel have long experience in this unit to achieve high product quality. (R)	2.00	.75
	9. The tasks of the unit require that new employees have to work with experienced R&D personnel as 'apprentices' for a long time to learn their job within important areas. (R)	2.42	.95
	Items 5-9 are adapted from Hakanson & Nobel (1998: 23).		
Organizational Distance	10. Which of the following statements characterized the organizational relationship between the source and recipient at the start of the transfer project?	4.91	2.99
(Alpha n/a)	Answers included: 1=Both were owned by the same parent for >5 years in the *same* division; 2=Both were owned by the same parent for >5 years in *different* divisions; 3=Either or both were acquired by the parent organization 2-5 years ago in the *same* division; 4=Either or both were acquired by the parent organization 2-5 years ago in *different* divisions; 5=Either or both were acquired by the parent organization <2 years ago in the *same* division; 6=Either or both were acquired by the parent organization <2 years ago in *different* divisions; 7=They were each owned by different parents working together through an *equity-based* alliance, joint venture or other agreement; 8=They were each owned by different parents working together through a *non-equity-based* alliance, joint venture or other agreement		
Physical Distance (Alpha = n/a)	11. A direct measure of physical distance in miles was calculated based on http://www.mailerssoftware.com or http://www.indo.com/distance.	1433.67	2302.53
Knowledge Distance (Alpha 0.63) (Items = 4)	To what extent do the following statements characterize the differences that existed between the source and the recipient unit? (Extent scale)		
	12. Given the overlap of the source and recipient's knowledge bases, source personnel could easily independently publish substantially the same scientific articles as recipient personnel.	2.86	1.34
	13. The recipient had the knowledge base necessary to easily understand and put to use the transferred know-how.	1.99	.81
	14. The source had the knowledge base necessary to easily understand how the recipient planned to use the transferred know-how.	2.13	1.01
	15. Differences in the knowledge bases made discussions very difficult. (R)	1.62	.82

Appendix A (*Continued*)

	Items in Questionnaire	Mean	S.D.
Norm Distance	To what extent do the following statements characterize how well the transfer project proceeded? (Extent scale)		
(Alpha 0.83) (Items = 2)	16. Interactions between the units unfolded immediately in a well-coordinated fashion.	2.61	.88
	17. The source immediately shared the recipient's definition of the situation.	2.60	.97
Learning Culture	To what extent do the following statements characterize how the recipient unit's personnel generally approach their work? (Extent scale)		
(Alpha 0.73)	18. They support failures that are the product of overreach.	2.12	.90
(Items = 4)	19. They encourage the capacity to be continually aware of internal processes and the external environment.	2.86	.79
	20. They anticipate future demands rather than rest on past successes.	2.86	1.02
	21. They believe that knowledge is more important than job title.	2.75	.93
	Items 18-21 from Yeung, et al. (1999: 160).		
Project Priority	22. The answer to question A is divided by the answer to question B to derive a percentage of staff assigned to the project		
(Alpha 0.76) (Items = 2)	A. How many people were employed in the recipient unit during the transfer project?	108.39	207.67
	B. How many of these people were devoted to this project on a full-time equivalent basis?	8.70	15.21
	23. Would you rate the priority of this transfer project on a 5-point scale (1=low, 5=high)?	3.78	1.40
Transfer Success	Now that the know-how has been transferred to the recipient, to what extent do the following statements characterize the feelings of the recipient unit personnel about this know-how? (Extent scale)		
(Alpha 0.76) (Items = 22)	24. They are willing to put in a great deal of effort beyond that normally expected to help this know-how transfer be successful.	2.69	.89
	25. They talk up this know-how to their friends as important to the organization's success.	2.46	.96
	26. They are proud to tell others that they are working with this know-how.	2.53	1.03
	27. They have been inspired by this know-how to do their very best performance.	2.38	1.05
	28. They are pleased that they learned this know-how over other know-how that they could have learned instead.	2.30	1.15
	29. They feel that there is very much to be gained personally by continuing to work with this know-how.	2.71	.76
	30. They really care about the implementation of this know-how.	3.00	.80
	31. They feel that, for them, this is the best of all know-how to work with.	2.11	1.02
	32. They feel that deciding to work with this know-how was a great decision on their part.	2.35	1.02
	33. They feel a very high degree of personal ownership of this know-how.	2.68	.97
	34. They feel a sense of responsibility for how this know-how gets used.	2.87	.81
	35. They resent the continued control that the source has over how to use this know-how. (R)	2.64	1.36
	36. They have had sufficient interaction with this know-how to develop an intimate understanding of it.	2.95	.83
	37. They have significantly invested their time, ideas, skills, and physical, psychological, and intellectual energies in this know-how and the related transfer process.	3.15	.67
	38. They have been able to exercise a great deal of discretion about how this know-how was transferred and how it is used.	2.78	.85
	39. How satisfied was the recipient with the quality of the know-how?	2.98	.97
	40. How satisfied was the recipient with the quality of the transfer process?	2.87	.81
	41. Once the recipient gained experience with the know-how, how did this change their satisfaction with the know-how?	3.03	.79
	42. How far was there any deviation to the planned start date of the transfer project?	2.25	1.49

Appendix A (*Continued*)

	Items in Questionnaire			Mean	S.D.
	43. How far was there any deviation to the planned first use of the know-how?			2.13	1.37
	44. How far was there any deviation to the planned achievement of satisfactory results from the know-how?			2.28	1.47
	45. How far was there any deviation to the planned and actual costs of the transfer?			2.49	1.49
	Items 24-32 are from Mowday, Steers & Porter (1979: 228). Items 33-38 are from Pierce, Van Dyne & Cummings (1992), and Pierce, Kostova & Dirks (2002). Items 39-45 are from Szulanski (1996). Questions 42-44 answers include: 1=Advanced more than one month, 2=Advanced less than one month, 3=No deviation, 4=Delayed less than one month, 5=Delayed by more than one month. Question 45 answers include: 1=Much (>30%) more than expected, 2=Slightly (<30%) more than expected, 3=As expected, 4=Slightly (<30%) less than expected, 5=Much less (>30%) than expected.				
Transfer Activities (Alpha n/a) (Items = 22)	46. How frequently did the source and recipient use the following transfer mechanisms and activities during the transfer project? (Frequency)			**Freq. Mean**	**Freq. S.D.**
	47. Approximate number of people involved from both units?	**People Mean**	**People S.D.**		
	Document exchanges	15.64	34.72	4.34	1.20
	Clarifying communications	14.34	36.37	5.12	.98
	Presentations	12.19	18.47	3.70	1.27
	Problem solving meetings	11.89	21.58	3.79	1.20
	Site visits/tours	8.03	14.66	2.88	1.23
	Joint technical training	3.78	5.58	2.19	1.48
	Job rotations	1.62	2.81	1.84	1.65
	Cultural training	.89	2.48	1.09	.84
	Joint project teams	7.16	14.88	2.95	1.68
	Joint development teams	5.39	14.53	2.43	1.60
	Joint management meetings	5.78	6.68	2.43	1.51
	48. How many months were the source and the recipient actively involved in this transfer project?			14.35	13.60
	Answer to question 46 was multiplied by relevant number of business days per month (e.g., daily=20.5; weekly=4.33), then multiplied by answer to question 47 (number of people involved), then multiplied by question 48 (duration of project in months).				
Key:	(Extent scale): Scale is a four point forced choice as follows: 1=To very little extent, 2=To little extent, 3=To large extent, 4=To very large extent.				
	(Frequency scale): 0=Don't know/not applicable, 1=Never, 2=Less than quarterly, 3=Quarterly, 4=Monthly, 5=Weekly, 6=Daily.				
	(R): Reverse coded.				
	All questions include a "Don't know/not applicable" option.				

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