Strategic Management Journal
Strat. Mgmt. J., **24**: 293–316 (2003)
Published online 20 December 2002 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/smj.297

GAINING FROM VERTICAL PARTNERSHIPS: KNOWLEDGE TRANSFER, RELATIONSHIP DURATION, AND SUPPLIER PERFORMANCE IMPROVEMENT IN THE U.S. AND JAPANESE AUTOMOTIVE INDUSTRIES

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We study sources of operational performance improvement in supplier partnerships. We argue that supplier performance will benefit most where time-bound relational assets have developed between a buyer and supplier and the firms exploit the resulting communication efficiency by transferring productive knowledge. We examine the effects of two forms of knowledge exchange together with the prior duration of the buyer–supplier relationship. We find similar interaction patterns in two survey samples of Japanese and U.S. automotive suppliers. The effect of ordinary technical exchanges on supplier performance improvement does not vary with relationship duration. The effect of higher-level technology transfer, however, grows more positive as relationship duration increases. Other results show relevant contrasts consistent with heterogeneous sourcing behavior between the two countries. The findings highlight the role of relational assets and show that it is important to distinguish between simple techniques and higher-level technological capabilities when studying interfirm relationships. This research extends the literatures on knowledge transfer, buyer–supplier partnerships, and the performance dynamics of interfirm and intrafirm relationships in general. Copyright © 2002 John Wiley & Sons, Ltd.

In recent years, researchers have paid increasing attention to the effects of supplier relationships on buyers' competitive advantage. Studies argued that by involving suppliers extensively in product and process development, assemblers (buyers) could gain faster product development cycles, lower input costs and higher end-product quality. Influential studies concluded that buyers should foster high-involvement relationships with suppliers (Womack, Jones, and Roos, 1990; Clark and Fujimoto, 1991). As such practices require ongoing knowledge exchange, Clark and Fujimoto (1991) and Martin, Swaminathan, and Mitchell (1998) argued for an information-based perspective on buyer–supplier relationships (see also Takeishi, 2001).

Another oft-mentioned factor benefiting buyers is long-established supplier links. Prior duration of a buyer–supplier relationship (link duration, henceforth) matters because what is effective in long-established relationships may not be in newly

Key words: vertical partnerships; interfirm collaboration; knowledge transfer; relation-specific assets; strategic sourcing; supply chain management
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Received 8 July 1999
Final revision received 22 August 2002

established ones (Stigler and Becker, 1977; Fichman and Levinthal, 1991a). Link duration measures the amount of experience that the supplier and the buyer have in dealing with each other, the resulting routines being described as relation-specific assets (Levinthal and Fichman, 1988). While many firms held as examples of successful knowledge management have developed comparatively long-lasting supplier links (Asanuma, 1989), research has shown little about whether or how firms with shorter links can benefit from knowledge-intensive sourcing, and generally how the benefits of knowledge transfer vary with link duration (see Martin, Mitchell, and Swaminathan, 1994; Dyer, Cho, and Chu, 1998).

This study examines the connection between knowledge transfer and link duration, and raises the issue of what it takes to enhance *supplier* performance. While past studies show that buyers benefit when suppliers are intensively and durably involved in knowledge exchange, it is less clear under what conditions this improves suppliers' operational performance.

Thus, the following questions arise: What sourcing-related knowledge transfer practices can improve a supplier's operational performance? And how do the benefits of these practices vary with link duration? In addressing these questions, we define a buyer–supplier relationship, or partnership, as the set of practices and routines that support economic exchanges between the two firms. A buyer–supplier link refers to the fact that the two firms have been doing business continuously for a given period of time (the link duration). A supplier's operational performance refers to the combination of product development efficiency, process improvements, quality conformity, and short lead time (Womack *et al.*, 1990). For simplicity, we refer to this below as performance.

We develop and test a multivariate model to examine what knowledge transfer practices are associated with supplier performance improvement. The analysis contrasts two forms of knowledge transfer: relatively simple technical exchanges, and technology transfer associated with higher-level capabilities. We also examine the moderating effects of prior link duration. By studying how the benefits of the two types of knowledge transfer vary with the duration of the buyer–supplier link, we seek to identify which practices can be replicated in more recent links and which cannot.

PREVIOUS LITERATURE

A shift occurred during the 1980s in the locus for conceptual strategy research on vertical interfirm relationships. Earlier research drew a sharp distinction between a firm and its buyers or suppliers and described the search for competitive advantage as a distributive game (e.g., Williamson, 1975; Porter, 1980). More recent research has emphasized the scope for value-adding relationships. Porter (1985) suggested that complementarities might arise between successive stages of the industry chain. Wernerfelt (1984, 1985) emphasized the role of inputs as a source of competitive advantage and argued that a buyer can benefit from long-established links allowing effective communication with suppliers. Research has also examined ways of overcoming obstacles to durable buyer–supplier cooperation. Axelrod (1984) showed how agents that develop a long-term track record of cooperation and reciprocate partners' behaviors could sustain cooperation despite short-term incentives to defect. Williamson (1985) argued that asset-specific investment could be sustained among nonintegrated firms provided it was reciprocated. Granovetter (1985) argued that embeddedness lends strength to ongoing relationships in the face of uncertain information. Fichman and Levinthal (1991a) and Asanuma (1989) used the concept of relation-specific skills or assets to describe how a buyer and supplier can develop over time distinctive routines that make ongoing collaboration more effective.

In summary, conceptual research now suggests that a firm can benefit from harnessing complementarities with suppliers. Such benefits can accrue more strongly to firms that foster durable linkages. However, it remains for empirical research to establish how complementarities should be pursued in practice, or how their effects may vary with link duration. Among the most wide-ranging empirical studies are those by Womack *et al.* (1990) and Clark and Fujimoto (1991) on the automotive industry. Foremost, they described two related features of the supplier arrangements made by effective assemblers. First, the division of labor can be extensive. Able suppliers are involved not only in manufacturing parts according to the supplier's detailed specification, but also in designing the parts and the corresponding manufacturing and technical processes. Second, this division of labor is accompanied by exchanges of knowledge about products and processes to ensure suitable coordination. The division of labor may vary accordingly over time, and varying it requires knowledge transfer between partners.

These influential studies provided a useful framework on buyer–supplier relationships and offered a range of recommendations for improving buyer performance. However, neither focused on supplier performance. For example, Clark and Fujimoto (1991) reported that an assembler could reduce the engineering hours and lead time required for new model development by delegating some or all component engineering responsibility to selected suppliers. Yet supplier performance could not be inferred because the measure of engineering hours excluded hours contributed by suppliers.

Some subsequent studies have dealt more explicitly with the roles of suppliers. They confirmed the importance of knowledge exchange between buyers and suppliers (e.g., Lamming, 1993; Nishiguchi, 1994). Other studies pointed to plausible connections between relationship continuity and partnership outcomes. In particular, Helper (1991a) discussed advantages of durable 'voice' relationships relative to more volatile 'exit' relationships. Dyer and Ouchi (1993) reported that buyer–supplier relations in Japan, which they held to be comparatively efficient, exhibited a high rate of repeat business such that links tended to last longer.

Other research has examined why long-established interfirm links may outperform shorter ones. It emphasized the learning requirements and time compression diseconomies inherent in developing efficient coordination and knowledge exchange between a buyer and a supplier. It takes time to develop the familiarity and expertise required for each partner to know when and how to draw on the other's resources and when and how to contribute resources (Wernerfelt, 1985; Asanuma, 1989). As two firms sustain their business relationship over time, they develop a joint understanding that is highly idiosyncratic but allows uniquely efficient communication (Stigler and Becker, 1977).[1] A concept that captures the ability of a buyer and a supplier to achieve such cospecialized coordination is that of relation-specific assets, or relational assets (or skills). Following Levinthal and Fichman (1988), Asanuma (1989), and Fichman and Levinthal (1991a), relation-specific assets refer to how, as a relationship endures over time, a supplier and a buyer stand to develop idiosyncratic interaction routines that allow them to communicate and collaborate more effectively.[2]

A critical feature of relation-specific assets is that their build-up is time-bound. Developing effective interfirm routines takes time, inherently (Arrow, 1974; Fichman and Levinthal, 1991a). As Kogut and Zander (1992: 390) put it:

> Complex organizations exist as communities within which varieties of functional expertise can be communicated and combined by a common language and organizing principles. To the extent that close integration within a buyer or supplier network is required, long-term relationships embed future transactions with a learned and shared code. In fact, the trading of know-how among firms often requires the establishment of long-term relationships.

Consistent with the notion that link duration is a primary determinant of the accumulation of relation-specific assets, studies have shown that after an initial acquaintance period, interfirm linkages become more interruption resistant as their

[1] A related organizational literature holds that relationships become embedded (Granovetter, 1985; Uzzi, 1996, 1997, 1999). It may be that another form of interfirm bond, trust, builds up over time. However, the empirical evidence to that effect is weak at best. Studies of the automotive industry in the United States, Korea, and Turkey have shown no statistical association between link duration and the level of trust in buyer–supplier relationships (Sako and Helper, 1998; Dyer and Chu, 2000; Wasti, 1999). In Japan Dyer and Chu (2000) found a positive association, but Sako and Helper (1998) did not. More generally, Axelrod (1984) and Heide and Miner (1992) pointed out that trust should not be confused with the familiarity resulting from long or repeated interaction. It is of course possible that goodwill trust matters (Zaheer, McEvily, and Perrone, 1998), though past research suggests that it would operate independently of relationship duration.

[2] For operational clarity, this concept can be contrasted with Williamson's (1985) notion of plain 'specific assets' (omitting 'relation'). *Relation*-specific assets arise from the continued association between a given buyer and a given supplier in a routine-building collaboration process (Fichman and Levinthal, 1991a; Dyer and Singh, 1998). Thus relation-specific assets are knowledge-based and team-embodied (rather than physical artifacts). They exhibit (plain) asset specificity in that their value is hampered if either partner is substituted (Wernerfelt, 1985).

prior duration increases, especially when the tasks given the supplier are more complex and uncertain (Levinthal and Fichman, 1988; Fichman and Levinthal, 1991b). This suggests that as link duration increases, a buyer and a supplier develop relation-specific routines so they become better able to share hard-to-transfer knowledge. However, to our knowledge, previous research has not examined systematically how the impact of knowledge transfer on performance varies with link duration.

Finally, past research points to the relevance of studying supplier performance. Descriptive studies have pointed out that even if the sharing of technical tasks and information benefits buyers, suppliers may receive no net benefit (e.g., Sakai, 1990; Ramsay, 1996). Dyer (1996) reported a composite measure of co-specific investments made by automotive buyers and suppliers that was positively correlated with the returns on assets of buyers, but unrelated with those of suppliers. Our study focuses on supplier performance, about which comparatively little is known.

PREDICTIONS

Our predictions use an evolutionary perspective whereby boundedly rational firms stand to improve performance by seeking and exploiting technological knowledge (Nelson and Winter, 1982). They build on three linked premises. The first is that operational performance improvement is an ongoing process responding to ongoing technological opportunities. Thus, studies have documented continuing change among automotive firms (Womack *et al.*, 1990; Clark and Fujimoto, 1991; Helper and Sako, 1995; Kotabe, 1998). Relatedly, for a buyer–supplier relationship to endure, each partner must remain satisfied with the other's past performance and outlook (Stigler and Becker, 1977; Fichman and Levinthal, 1991a). Thus, all else equal, the average *absolute* performance of suppliers in longer-established relationships should be higher than that of suppliers that have yet to prove themselves over time. To avoid this potential survival bias, we focus instead on the recent *trend* in a supplier's performance. Specifically, the outcome of interest is the improvement in a supplier's operational performance over the last 2–3 years. A 2–3 year period is useful and sufficient to assess the occurrence and consequences of various forms of knowledge transfer (e.g., Galbraith, 1990).

Our second premise is that gains in performance arise from intentional and organized knowledge transfer between a supplier and a buyer. The third premise is that the ability to benefit from knowledge transfer depends on prior link duration. Building on the second premise, we discuss the effects of two forms of knowledge transfer. Then, consistent with the third premise, we examine how the benefits from knowledge transfer can vary with the prior duration of the buyer–supplier relationship. Our empirical analyses control for several other factors affecting knowledge flows and supplier performance. Figure 1 presents a conceptual framework for this study.

Exchanges of knowledge

If knowledge transfer is expected to affect the outcome of buyer–supplier relationships, then the extent and complexity of the knowledge transfer deserve attention. Existing research suggests a distinction between relatively simple technical exchanges and higher-level sharing or transfer of whole technological capabilities (Teece, 1977; von Hippel, 1988). Conceptually, these two forms of exchange differ in the scope and level of the knowledge involved. A technique consists of discrete know-how required to solve a particular operational problem, so technical communications pertain to the relatively narrow and simple informational resources necessary to handle engineering issues case by case. By contrast, a technology is a broader body of knowledge encompassing a set of related techniques, methods, and designs applicable to an entire class of problems (Rosenberg, 1982; Arora and Gambardella, 1994). Thus its sharing or transfer involves higher-level capabilities (Granstrand and Sjolander, 1988; Dussauge, Hart, and Ramanantsoa, 1992; Szulanski, 1996).

The associations between technology and capability, and between technique and resource, add meaning to the distinction between technical and technological knowledge. Relative to discrete resources, capabilities are higher-order, more complex sets of routines with broader applications (Nanda, 1996). Technical knowledge, consisting of narrower and more independent pieces of information, is a form of resources (Nanda, 1996). By contrast, capabilities are related to higher-level, cumulative technology that is harder to

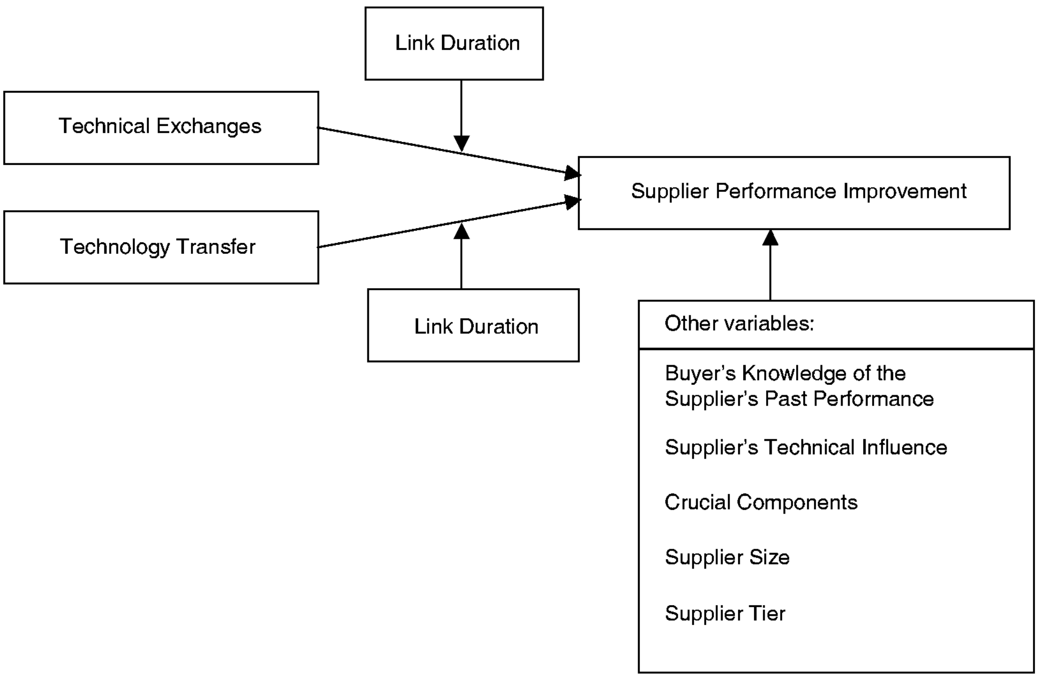

Figure 1. Conceptual framework

develop and mold (Dosi, 1988; Nelson, 1991; Helfat, 1997). Transferring technology, sharing it, or using it in support of a partner is a challenging collaborative process. For simplicity, we use the term technology transfer to refer to scenarios where firms transfer, share, and/or deploy technology on their partner's behalf. These scenarios all involve complex challenges of codification and communication capacity, and are intertwined in practice (Mogavero and Shane, 1982; Godkin, 1988). While exchanging technical knowledge can also be difficult, the challenge is more circumscribed.

The distinction between technical exchanges and technology transfer also has organizational implications. The coordination required for exchanging small-scale technical knowledge is typically simple. Arranging regular meetings or long-term personnel visits, for example, is straightforward if it involves autonomous individuals or small work units (von Hippel, 1988; Nishiguchi, 1994). As technical information tends to be explicit or at least codifiable, its exchange is a matter of verbal or written communication (Kogut and Zander, 1992). By contrast, technology transfer involves a greater scope of activities and higher-level organizing principles (Rosenberg, 1982; Collis, 1991). It requires extensive and dedicated coordination, as large and functionally diverse groups interact both within and across firms for sustained periods of time (Teece, 1977; Galbraith, 1990). The greater the scope of a knowledge transfer project, and the more complex the knowledge, the more tacit and causally ambiguous the knowledge tends to be (Kogut and Zander, 1993). This renders technology transfer particularly costly (Teece, 1977; Szulanski, 1996).

Technical exchanges

Buyer–supplier relationships involve ongoing mutual adjustment between the buyer's and the supplier's design and production operations. Many such adjustments are made readily by personnel sharing explicit engineering knowledge. This entails small-scale exchanges of technical information (technical exchanges, in short). Past studies have argued that these help improve the buyer's performance (Clark and Fujimoto, 1991; Lamming, 1993). Suppliers stand to benefit likewise when the partners steadily share technical knowledge to solve problems and enhance products and processes (Takeishi, 2001). Therefore, we expect a positive association between supplier performance improvement and the involvement of the partners in ongoing technical exchanges.

Hypothesis 1: The more technical exchanges between the buyer and the supplier, the higher the supplier performance improvement relative to 2–3 years earlier.

Technology transfer

In other cases, small-scale technical exchanges do not suffice to solve a particular problem or exploit a particular opportunity. Instead, more lumpy and complex technology is required. Such knowledge transfer requires larger-scale commitments of time and groups of experts, with extensive coordination (Galbraith, 1990). Technology transfer, as we label it in short, refers to concerted projects that allow one partner to access or replicate complete technological capabilities of the other partner. Properly implemented, technology transfer enables a more efficient division of labor (Clark and Fujimoto, 1991). It also allows distinct improvements in technological competence throughout the industry chain (Lamming, 1993). Technology transfer should therefore be positively associated with supplier performance improvement.

Hypothesis 2: The more technology transfer between the buyer and the supplier, the higher the supplier performance improvement relative to 2–3 years earlier.

Beyond these main effects, research suggests that buyers seek to further the benefits of knowledge transfer by shaping the balance of technical exchanges and technology transfer. Asanuma (1985, 1989) argued that Japanese automotive assemblers may engage in ongoing narrow exchanges but prefer to delay more demanding collaboration until the suppliers have proven themselves and become familiar (see also Nishiguchi, 1994; Dyer and Nobeoka, 2000). We argue that time-bound communication efficiencies can explain such patterns. Knowledge transfer is more difficult when buyers and suppliers lack familiarity. Thus MacDuffie and Helper (1997) found that Honda, though a highly capable assembler, experienced mixed success in transferring practices to three local suppliers that it had added relatively recently in the United States. In response, Honda focused on narrower projects akin to technical exchanges. This suggests that letting relationships mature, and thereby accumulate relation-specific assets, fosters more successful knowledge transfer from the buyer's standpoint. We examine next how the impact of knowledge transfer stands to vary with link duration, focusing on supplier performance.

Moderating impact of link duration

We do not expect the trend in a supplier's performance, by itself, to be inherently higher in longer links. Indeed, if parties to a longer-established relationship develop a longer-term horizon shielding the link from interruption in the presence of short-term performance dips (Granovetter, 1985; Fichman and Levinthal, 1991b), the main effect of link duration may appear weak or slightly negative.[3] This will also be true insofar as newer relationships are able to exploit easy opportunities for improvement while older partnerships must build past those by tackling less obvious improvement projects. Hence, we do not predict a main effect of link duration on supplier performance improvement.

However, we expect longer-established links, because they allow more relation-specific assets to develop, to magnify some of the performance effects hypothesized above. The longer a buyer–supplier link endures, the more the relation-specific assets between the two parties stand to make pairwise knowledge transfer efficient relative to alternative partner sets.

In simple technical exchanges, the scope of each knowledge transfer is narrow. Under these circumstances, relation-specific assets need not be at their most useful. Nevertheless, Uzzi (1996, 1997) found that solidly embedded relationships facilitated the continuous exchange of 'fine-grained' information, akin to simpler technical exchanges,

[3] An alternative possibility, as an anonymous reviewer pointed out, is that firms with long-term links become complacent and under-perform. This presumes that the buyer and the supplier face relatively weak incentives in relation to each other. The buyers we study have increasingly learned to combat complacency by monitoring suppliers closely and eliciting continuous improvement (Helper and Sako, 1995; Mudambi and Helper, 1998). Indeed, long-tied partners are plausibly better able to overcome hazards of opportunism (Delios and Henisz, 2000). Nevertheless, the alternative scenario may explain the relative inefficiency attributed to in-house parts divisions of some automotive assemblers that are shielded from outside competition. Our sample excludes such closely held divisions. It consists of suppliers (and buyers) that have been selected against competition over time so they could not afford durable complacency.

that in turn benefited each firm's ability to anticipate market changes and respond to unforeseen circumstances. This suggests that the benefits of technical exchanges may increase with link duration, though the magnitude of this interaction is in question. Our third hypothesis is:

Hypothesis 3: The positive association between technical exchanges and supplier performance improvement becomes stronger as link duration increases.

The benefits of a long prior relationship stand to be larger yet when it comes to higher-level technology transfer. Technology transfer requires diverse functions of the supplier and the buyer to interact over multiple issues simultaneously. The resulting ambiguity and tacitness exacerbate the burden of interfirm communications while defeating conventional means of transmitting explicit information (Teece, 1977; Galbraith, 1990). Under these circumstances, the benefits of having had the time to develop more relation-specific assets become all the more salient, as the resulting shared understanding facilitates the transfer of complex technological knowledge. Therefore we expect that technology transfer will make a stronger contribution to supplier performance improvement when the supplier and the buyer have developed a longer-lasting relationship.

Hypothesis 4: The positive association between technology transfer and supplier performance improvement becomes stronger as link duration increases.

Other variables

In testing the hypotheses, we control for several plausible alternative mechanisms for knowledge transfer and supplier performance improvement. We include variables that measure two potential knowledge substitutes: how knowledgeable the buyer is about the supplier's past performance, and how much technical influence the supplier has. Japanese firms have been found particularly effective at leveraging such expertise (Asanuma, 1985; McMillan, 1990). We also control for whether the knowledge associated with the component(s) is crucial for the buyer's competitiveness, and for supplier size and tier. We have no a priori expectation as to the direction of these effects.

METHODS

Sample and data collection

To test our hypotheses, buyer–supplier relationships with a diverse history need to be examined. The automotive industry is particularly suitable for this purpose (Martin, Mitchell, and Swaminathan, 1995). In this context, many lessons have been drawn from Japanese industry, but examining a complementary context such as the United States is important in arriving at informed conclusions (Lamming, 1993). Finally, obtaining detailed information about knowledge transfer requires primary data collection. Previous studies of knowledge transfer in the automotive industry have used qualitative methods. They yielded valuable insights but leave unanswered the question of generalization outside Japanese firms (Asanuma, 1985; Nishiguchi, 1994), and particularly outside leading buyers such as Honda (MacDuffie and Helper, 1997) and Toyota (Dyer and Nobeoka, 2000). Accordingly, we conducted a broad survey of U.S. and Japanese suppliers.

During the questionnaire development, we consulted extensively with executives of automotive component suppliers and assemblers. The questionnaire was developed in English and then translated into Japanese. The Japanese version was subsequently back-translated into English by a third party to confirm that it was an equivalent translation. Each version of the questionnaire was pretested with small groups of executives, from U.S. automotive components suppliers in the United States (in English) and from Japanese suppliers in Japan (in Japanese). The pretest further assured that there were no translation effects on executives' interpretation of either version. Subsequently, the data were collected in 1996 by a mail survey of independent automotive component suppliers in the United States and Japan. The sampling procedure employed in the two countries is as follows.

In the United States, the Directory of the Motor and Equipment Manufacturers Association was the basis for the sampling frame.[4] First, an introductory participation request letter was sent to the

[4] Specifically, if a company was a stand-alone entry, it was included as a randomly selectable case. If a company had no more than three subsidiaries, the parent and only one of its subsidiaries were considered. If a company had more than three subsidiaries, then the parent and two subsidiaries were considered. The entries that did not have information on some

presidents/CEOs of 400 randomly selected firms and their major affiliates, asking them to provide names and addresses of managers directly responsible for the respective firms' supply relations with other parts suppliers and/or with automobile manufacturers. At this stage 185 firms expressed willingness to participate in the study and provided a manager-in-charge to contact. A questionnaire was then mailed to the 185 managers, along with a personalized cover letter that explained the nature of the study and informed the managers that their names had been provided by their respective company heads. All survey solicitation letters indicated that companies participating in the survey would receive a summary of the research and comparative benchmark results tailored to individual firms. The managers were asked to choose their major buyer (another automotive components manufacturer or an automobile manufacturer) in the United States and to respond to all questions with respect to their firm's relationship with that buyer. After one follow-up letter, 104 questionnaires were received, for a response rate of 26.0 percent of the original sample or 56.2 percent of those who were identified to participate. After eliminating responses with missing data, the sample for analysis consists of 97 questionnaires, a rate of 24.3 percent or 52.4 percent of first-stage respondents.

In Japan, Teikoku Databank's COSMOS database provided the sampling frame. Teikoku Databank, founded as a corporate credit research firm in Japan in 1900, produces the largest and most reputable corporate database in Japan. We purchased the list of the 600 largest automotive components suppliers, based on annual sales. Twenty-three records were unusable due to missing addresses, leaving an initial sample of 577. Given the costly nature of international survey research, we contracted out survey execution (questionnaire mail-out, collection, and data entry) to a highly reputable independent marketing research company in Tokyo, Japan. The survey solicitation letters were sent to the presidents/CEOs of those Japanese suppliers and offered the same incentives as for U.S. respondents. Following the first mail-out and a follow-up letter a few weeks later, 123 questionnaires were collected with a response rate of 21.3 percent. The final sample, upon exclusion of cases with missing data, consists of 105 responses (18.2%).

In defining both samples, we excluded subsidiaries where an automotive assembler was a major shareholder (20% or more). Thus, the respondents can be considered autonomous of the buyers. We excluded suppliers owned by foreign firms, including Japanese-owned suppliers in the United States and the few U.S.-owned facilities in Japan. Because we asked the respondents about their major domestic customer, all Japan-based respondents replied with respect to a Japanese buyer in Japan. Likewise all U.S. respondents reported locally based buyers, except one response that was excluded from the sample to ensure maximum contrast. The responses cover a wide range of products and firm sizes and are representative of the economics of the underlying sector.[5]

As reported in Table 1, the U.S. and Japanese responses are demographically comparable. Most respondents held upper-management positions. In the United States and Japan respectively, they had 4.66 and 5.58 years of experience in their current positions ($t = 1.19$, $p = 0.23$) and 14.01 and 19.90 years with the same company ($t = 3.68$, $p = 0.001$). This exceeds the 2–3 year timeframe for measuring our dependent variable, adding to confidence that respondents were knowledgeable. Given Japanese life-long employment practices, the difference in corporate tenure is understandable; however, the respondents had comparable experience in their current positions. On average, the U.S. and Japanese suppliers are similar in annual sales (about $440 million) and in total employment (3100–4500, not statistically different). These data show that the respondents have requisite expertise and involvement in supply chain management, and that the U.S. and Japanese samples match well.

Two issues commonly raised concerning survey methodology are nonresponse bias and common method variance. We examined the nonresponse

vital demographic characteristics were excluded. These criteria were used to generate the sampling frame, from which 400 companies were randomly selected.

[5] For the U.S. data, although the source directory does not represent small jobshop-type parts suppliers, it represents a significant portion of the automobile parts industry. For the Japanese data, the 600 largest suppliers account for more than 90 percent of sales to the Japanese automobile manufacturers. As a result, each sample may under-represent the smallest firms. However, our focus was on representativeness of the economic impact of buyer–supplier relationships in the industry—which this achieves—rather than pure randomness of the population.

Table 1. Sample characteristics

Nationality	Respondent			Company	
	Job position	Number of years in current position	Number of years with the company	Average sales (in millions)	Employment
Japanese	• President/CEO—11 • Vice President—1 • Director—50 • Marketing/ Manufacturing/ Operations/General Manager—24 • Unreported—19	5.58 years	19.90 years	¥47,524.3 mil.	4527.3
U.S.	• President/CEO—9 • Vice President—36 • Director—13 • Marketing/ Manufacturing/ Operations/General Manager—39 • Unreported—0	4.66 years	14.01 years	$440.0 mil.	3110.9
Note	Japanese and U.S. job titles are not necessarily comparable. In some cases, director or functional manager positions in Japan are comparable to vice president positions in the United States	$t = 1.19$, $p = 0.23$	$t = 3.68$, $p = 0.001$	The average annual sales would be comparable at ¥162/$	$t = 0.70$, $p = 0.48$

issue with the procedure suggested by Armstrong and Overton (1977). We performed t-tests comparing early and late respondents on key demographic variables, namely supplier tier, sales volume, and employment. In each sample we found no significant differences between early and late respondents. This suggests that nonresponse would not likely bias the findings. We used Harman's one-factor test to address the issue of common method variance. If that were a serious problem, we would expect a single factor to emerge from a factor analysis or one general factor to account for most of the covariance in the independent and criterion variables (Podsakoff and Organ, 1986). We performed factor analysis on items related to the predictor variables and criterion measure. No general factor was apparent in the unrotated factor structure. Therefore, no common method variance problem was detected.

Measures and statistical methods

The measures used for this study are presented in the Appendix. All multi-item measures are based on 5-point Likert scales. In order to assess construct validity, items across the scales were subjected to principal components factor analysis with varimax rotation. Appropriate factor solutions were obtained after iterated removal of items that failed to load on any single factor. The pattern of observed loadings indicates that the multi-item scales measure independent constructs, thus further supporting unidimensionality and discriminant validity of the scales. Each multi-item measure was obtained by computing the average score provided by the respondent across the relevant items. Table 2 reports descriptive statistics.

Criterion variable

The measure of supplier performance captures a supplier's performance improvement relative to its position 2–3 years earlier. Such a trend measure avoids the relationship-survival bias that might result from comparing the absolute performance of buyer links with sharply different durations. The measure includes dimensions of operational performance that are central concerns

Table 2. Descriptive statistics: means, standard deviations and correlations

	Mean	S.D.	1	2	3	4	5	6	7	8	9
U.S. sample ($N = 97$)											
1. Supplier Performance Improvement	3.552	0.800	1.000								
2. Technical Exchanges	3.827	0.621	0.383	1.000							
3. Technology Transfer	2.518	0.723	0.209	0.416	1.000						
4. Buyer's Knowledge of Supplier's Past Performance	3.799	0.657	0.203	0.233	0.262	1.000					
5. Supplier's Technical Influence	3.804	0.866	0.037	0.084	0.161	0.158	1.000				
6. Crucial Components	0.351	0.480	0.007	0.065	0.055	0.185	0.155	1.000			
7. Link Duration	26.32	21.30	0.064	0.108	0.125	−0.031	0.056	0.033	1.000		
8. Supplier Size (employees)	3111	7992	0.121	0.147	−0.029	0.000	−0.029	−0.092	0.208	1.000	
9. First-Tier Supplier	0.474	0.502	0.308	0.142	0.056	0.284	0.198	0.124	0.144	−0.080	1.000
Japanese sample ($N = 105$)											
1. Supplier Performance Improvement	3.438	0.836	1.000								
2. Technical Exchanges	3.814	0.701	0.391	1.000							
3. Technology Transfer	2.945	0.721	0.577	0.573	1.000						
4. Buyer's Knowledge of Supplier's Past Performance	3.176	0.649	0.515	0.440	0.549	1.000					
5. Supplier's Technical Influence	3.052	0.785	0.621	0.346	0.500	0.429	1.000				
6. Crucial Components	0.390	0.490	0.077	0.207	0.285	0.175	0.103	1.000			
7. Link Duration	36.92	14.85	0.115	0.204	0.053	0.081	0.046	0.067	1.000		
8. Supplier Size (employees)	4527	18968	−0.145	0.045	0.060	0.063	−0.053	0.062	0.014	1.000	
9. First-Tier Supplier	0.695	0.463	0.237	0.384	0.330	0.133	0.203	0.021	0.333	0.004	1.000

for supplier firms and that the respondents could expertly assess. Interviews with executives of supplier firms indicated that improvements in product design, process design, product quality, and lead time are key indicators of their performance and that a 2–3-year timeframe is suitable to assess knowledge transfer and its consequences. These performance dimensions are also consistent with those used by assemblers to assess suppliers (Cusumano and Takeishi, 1991; Choi and Hartley, 1996). Therefore, we use items measuring trends in product design, process design, quality, and lead time achievements to represent supplier performance improvement.[6] These four items, when introduced in the factor analysis alongside all the items that make up our independent variables, loaded onto a single measure (Cronbach's alpha = 0.83). This variable was labeled Supplier Performance Improvement.

Predictor variables

The measure of Technical Exchanges contains six items pertaining to common, informal communication between engineers (Cronbach's alpha = 0.83). The measure of Technology Transfer consists of five items describing transfer of higher-level technological capabilities (Cronbach's alpha = 0.83).

As the distinction between technique (Technical Exchange) and technology (Technology Transfer) is important to the study, we used confirmatory factor analysis to verify that these two measures are distinct. We compared our two-factor model against a single-factor model that would apply if the distinction were blurred in measurement (Steenkamp and van Trijp, 1991). The results unambiguously favor the two-factor specification. A large χ^2 difference indicates that a single factor cannot approximate the two measures ($\chi^2_{\text{diff}} = 143.96$, $p < 0.001$). The parsimonious goodness of fit index (PGFI, the common measure of absolute fit parsimony) and parsimonious normed fit index (PNFI, the common measure of comparative fit parsimony) both exceed 0.65 in the two-factor model but fall below 0.63 in the alternative. The root mean squared error of approximation (RMSEA, a standard indicator based on residuals) is on the 'good' side of the 0.10 cut-off with our two-factor specification (0.09) but poor with a single factor (0.14). Finally, interfactor correlation is significantly below 1 ($p < 0.001$), indicating discriminant validity to our model that the single-factor model would lack (Bagozzi and Yi, 1993). In summary, the basic and confirmatory factor analyses alike indicate a sharp and valid distinction between Technical Exchanges and Technology Transfer.

The moderating variable, Link Duration, was measured as the number of years since the buyer and the supplier began their business relationship. Some studies argue that because experience tends to accumulate at a decreasing rate, a nonlinear transformation of link duration may be appropriate (e.g., Heide and Miner, 1992). Thus we report two sets of estimates. One uses the untransformed value of link duration. In the other we take its natural logarithm (Cohen and Cohen, 1983).

Other variables

Control variables are described in the Appendix. Each may affect supplier performance and may also explain firms' propensities to transfer technology and/or develop a long-term link. Two multi-item measures represent the buyer's familiarity with the supplier's past performance and the supplier's technical influence. Their alphas exceed 0.70. A binary measure controls for the class of components the supplier makes, based on the importance of the underlying expertise for assemblers. Supplier size is measured as the number of the firm's employees. This measure provides consistency across countries independent of currency exchange rates. To ascertain that any skewness did not affect our results, we replicated our analyses after log-transformation of the supplier size measure. Finally, a binary variable indicates first-tier supply relationships.

Regression methods

Estimates were obtained by ordinary least squares regression. Upon examining residuals visually and

[6] The existing literature argues consistently that near-simultaneous improvement along multiple performance dimensions is possible and indeed expected, due to the systemic nature of automotive production. See, for example, Womack *et al.* (1990); Clark and Fujimoto (1991); Dyer and Ouchi (1993); Lamming (1993); Helper and Sako (1995).

conducting White's (1980) test, there is no evidence of heteroskedasticity in the data. OLS regression is appropriate under these circumstances.[7]

We conducted a Chow test to examine whether the pattern of coefficients is the same for the U.S. and Japanese samples. For basic models excluding interaction effects, the Chow test $F(8,195)$ was 3.82. This indicates that the regressions differ between the two samples, but not overwhelmingly so. Accordingly, we report separate analyses of the U.S. and Japanese samples. This *etic* approach makes it possible to observe similarities and differences between countries in response to similar factors (Craig and Douglas, 1999). It allows estimated slopes and intercepts to vary, and therefore permits a more thorough comparison of the effects of knowledge exchange and link duration in the two samples. Etic research designs have been commonly used in our research context (e.g., Cusumano and Takeishi, 1991; Helper and Sako, 1995; Dyer *et al.*, 1998).

RESULTS

Table 3 reports the results for the U.S. sample. Table 4 reports the same specifications for the Japanese sample. For each country, two sets of analyses are reported: one where link duration is untransformed and the other where it is log-transformed. Each table reports four analyses for each specification of link duration. The first analysis contains a base model without interaction terms. The second includes a single interaction term, between Link Duration and Technical Exchanges. The third contains a single interaction term, between Link Duration and Technology Transfer. The fourth analysis includes both interaction terms. Below we discuss each variable in turn. In addition, we conducted comprehensive multivariate F-tests of matched variables (e.g., a main effect and its interaction). Unless otherwise mentioned, the F-tests simply confirm the univariate results. The discussion below reports interactions between our continuous variables. We also replicated the analyses with up to four splits of each key variable (e.g., dummies and interactions for quartiles of Link Duration) and found consistent results.

Results for the U.S. sample

The adjusted R^2 for the U.S. results in Table 3 is in a satisfactory range (0.173–0.209). The base analysis with untransformed link duration is reported as Model 1.1. The coefficient for Technical Exchanges is positive ($p < 0.01$). The coefficient for Technology Transfer is positive but smaller in magnitude and not statistically significant. Model 1.2 adds the interaction between Technical Exchanges and Link Duration. The main effect of Technical Exchanges and its cross-term with Link Duration are both positive. However, only the main effect is statistically significant. These results support Hypothesis 1 but not Hypotheses 2 and 3. Only Technical Exchanges has a main effect, and that positive effect does not become substantially stronger as link duration increases.

Model 1.3 reports the interaction between Technology Transfer and Link Duration. The main effect of Technology Transfer remains nonsignificant, as does that of Link Duration. The cross-term, meanwhile, is positive and statistically significant. This provides support for Hypothesis 4. Model 1.4 includes both interaction effects. It confirms the interactive effect of Technology Transfer and Link Duration after controlling for the interaction of Technical Exchanges and Link Duration. The latter interaction is not significant. An F-test of the two cross-terms indicates that they are not significant as a pair ($F = 1.34$). However, the interaction of Technology Transfer and Link Duration is. Since the two-interaction models throughout Tables 3 and 4 simply confirm the simpler models, the remainder of the discussion emphasizes the interpretation of more parsimonious models with zero or one interaction.

The last four models of Table 3 report results for the U.S. sample when link duration is log-transformed. They are generally similar to the first four. One difference is found when the cross-term of Technical Exchanges and Link Duration (log-transformed) is introduced (Models 1.6 and 1.8).

[7] Given that some variables have multiple indicators, an alternative method to test the full model might be structural equation modeling (SEM). However, sample size considerations preclude the use of SEM. The ratio of observations to estimated parameters would fall far short of accepted guidelines (Bentler and Chou, 1987). This is even more so when it comes to our interaction hypotheses, since testing such hypotheses by SEM customarily requires splitting each sample into at least two subsamples (preferably more), and doing so for each interaction of interest.

Table 3. OLS estimates of supplier performance improvement: U.S. sample ($N = 97$)

Variables	Predicted sign [hypothesis]	Model 1.1.	Model 1.2.	Model 1.3.	Model 1.4.	Model 1.5.	Model 1.6.	Model 1.7.	Model 1.8.
		Link duration variable untransformed				Link duration variable log-transformed			
Predictor variables									
Technical Exchanges	+[H1]	0.387***	0.311**	0.368***	0.394**	0.387***	0.289	0.353***	0.273
		(0.122)	(0.171)	(0.120)	(0.174)	(0.135)	(0.417)	(0.135)	(0.430)
Link Duration × Technical Exchanges	+[H3]		0.004		−0.002		0.142		0.109
			(0.007)		(0.007)		(0.151)		(0.159)
Technology Transfer	+[H2]	0.055	0.044	−0.041	−0.056	0.083	0.065	−0.288	−0.273
		(0.119)	(0.120)	(0.128)	(0.162)	(0.119)	(0.119)	(0.262)	(0.271)
Link Duration × Technology Transfer	+[H4]			0.008**	0.008**			0.183**	0.176*
				(0.004)	(0.004)			(0.099)	(0.111)
Other variables									
Buyer's Knowledge of Supplier's Past Performance		0.056	0.020	−0.026	−0.017	0.050	−0.030	0.016	−0.027
		(0.124)	(0.138)	(0.129)	(0.137)	(0.126)	(0.143)	(0.127)	(0.142)
Supplier's Technical Influence		−0.039	0.054	−0.035	−0.029	−0.044	−0.075	−0.060	−0.076
		(0.089)	(0.013)	(0.088)	(0.092)	(0.010)	(0.093)	(0.089)	(0.093)
Crucial Components		−0.088	−0.095	−0.097	−0.095	−0.109	−0.098	−0.150	−0.138
		(0.169)	(0.170)	(0.166)	(0.167)	(0.171)	(0.171)	(0.171)	(0.172)
Link Duration		−0.002	−0.018	−0.016	−0.017	−0.079	−0.404	−0.328	−0.582
		(0.004)	(0.027)	(0.016)	(0.026)	(0.088)	(0.582)	(0.363)	(0.580)
Supplier Size (employees, in thousands)		0.010	0.009	0.009	0.010	0.011	0.009	0.010	0.009
		(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
First-Tier Supplier		0.435***	0.479***	0.494***	0.482***	0.462***	0.537***	0.509***	0.548***
		(0.160)	(0.175)	(0.160)	(0.172)	(0.163)	(0.174)	(0.163)	(0.173)
Intercept		1.74**	2.24**	2.63**	2.49**	1.85***	4.09**	3.26**	4.41**
		(0.604)	(0.999)	(0.740)	(0.993)	(0.676)	(1.98)	(1.05)	(1.97)
Adjusted R^2		0.182	0.176	0.209	0.200	0.173	0.169	0.188	0.183

Standard errors are in parentheses.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$ (one-tailed)

The main effect of Technical Exchanges becomes nonsignificant, though it is still positive and quite high in magnitude. This may be due to correlation inherent in the interaction design. Indeed, the joint F-test of Technical Exchanges and its cross-term is significant ($F = 5.21$, $p < 0.01$). Since both effects are positive and the main effect alone is otherwise strong (Models 1.5 and 1.7), this still suggests support for Hypothesis 1. Meanwhile, support for Hypothesis 4 remains strong.

Examination of the coefficients provides insight into the conditions under which technology transfer is likely to be beneficial. We base the analysis on Model 1.3 as it contains all relevant effects and is parsimonious (adjusted $R^2 = 0.209$). The partial derivative of the equation with respect to technology transfer is

$$\partial(\text{Supplier Performance Improvement})/\partial(\text{Technology Transfer}) = -0.041 + 0.008^*(\text{Link Duration})$$

This indicates that the overall effect of Technology Transfer could be negative if Link Duration were very low. The effect becomes positive if Link Duration exceeds approximately 5 years.[8] This means that Technology Transfer can be beneficial, but only provided that the buyer and supplier have interacted long enough. Interestingly, 5 years is approximately the length of a product design cycle in the U.S. automotive industry (see Clark and Fujimoto, 1991). Most observations in our sample operate in the range where Technology Transfer improves performance overall, though seven cases have links of 5 years or shorter. Extrapolating this result suggests a distinct challenge for just-formed relationships: premature use of technology transfer may harm supplier performance. Conversely, the pay-off of transferring technology is particularly high in links of very long duration.

Throughout Table 3, the main effect of Link Duration is nonsignificant. This indicates that long-established links do not promote performance improvement by themselves; however, they can help when combined with active technology transfer practices. Among control variables, only first-tier status is significant. Its positive effect is consistent with executives' reports that U.S. assemblers sought to thin first-tier ranks based on performance in years preceding the study. While supplier tier is correlated with the criterion and predictor variables, the results are not sensitive to its inclusion.

In summary, the results for the U.S. sample provide support for Hypotheses 1 and 4. Simple technical exchanges can enhance supplier performance, and this effect is independent of whether a buyer and supplier have established familiarity through a long-established relationship. Technology transfer has no independent main effect but its combination with longer link duration is beneficial.

Results for the Japanese sample

The results for the Japanese sample are shown in Table 4. In Model 2.1, Technical Exchanges is nonsignificant, while Technology Transfer is positive and significant. The cross-term of Technical Exchanges and Link Duration (Model 2.2) is nonsignificant. Thus, the impact of Technical Exchanges is not contingent on link duration. Hypotheses 1 and 3 are not supported in this sample.

When the interaction of Technology Transfer and Link Duration is included, as reported in Model 2.3, the cross-term takes a positive sign and is statistically significant. The main effect of Technology Transfer becomes nonsignificant. This specification is consistent with Hypothesis 4. Hypothesis 2 appears supported absent the interaction term, but is not supported in the full model. These results are confirmed with the log-transformed version of Link Duration in Models 2.5–2.8. The interaction with Technology Transfer attains stronger statistical significance ($p < 0.05$) if Link Duration is log-transformed (Models 2.7 and 2.8). Overall, technology transfer can be a powerful driver of supplier performance, and its benefits accrue more in buyer–supplier links that have been established longer.

Examination of the coefficients again provides insight into the conditions for beneficial technology transfer. We analyze Model 2.7 as it contains all relevant effects and is most parsimonious (adjusted $R^2 = 0.516$). Taking the partial

[8] Setting the derivative to 0 and solving for Link Duration yields Link Duration = 0.041/0.008 = 5.1 years. In other words, other factors being held constant, the effect of technology transfer on supplier performance improvement is estimated to become positive once the buyer–supplier relationship has lasted 5.1 years in the United States.

Table 4. OLS estimates of supplier performance improvement: Japanese sample ($N = 105$)

Variables	Predicted sign [hypothesis]	Model 2.1.	Model 2.2.	Model 2.3.	Model 2.4.	Model 2.5.	Model 2.6.	Model 2.7.	Model 2.8.
		Link duration variable untransformed				Link duration variable log-transformed			
Predictor variables									
Technical Exchanges	+[H1]	0.007	−0.056	0.102	0.180	0.006	−0.347	0.096	0.352
		(0.107)	(0.245)	(0.122)	(0.290)	(0.106)	(0.495)	(0.120)	(0.611)
Link Duration × Technical Exchanges	+[H3]		0.004		−0.004		0.125		−0.096
			(0.006)		(0.007)		(0.141)		(0.174)
Technology Transfer	+[H2]	0.339***	0.318***	−0.031	−0.041	0.339***	0.320***	−0.315	−0.366
		(0.117)	(0.119)	(0.240)	(0.286)	(0.116)	(0.118)	(0.502)	(0.596)
Link Duration× Technology Transfer	+[H4]			0.009*	0.010*			0.245**	0.287**
				(0.006)	(0.007)			(0.140)	(0.166)
Other variables									
Buyer's Knowledge of Supplier's Past Performance		0.263**	0.238**	0.219**	0.240**	0.259**	0.230**	0.215**	0.237**
		(0.112)	(0.114)	(0.114)	(0.115)	(0.112)	(0.113)	(0.112)	(0.114)
Supplier's Technical Influence		0.403***	0.370***	0.399***	0.405***	0.411***	0.403***	0.402***	0.407***
		(0.088)	(0.088)	(0.088)	(0.088)	(0.088)	(0.085)	(0.088)	(0.088)
Crucial Components		−0.117	−0.115	−0.093	−0.093	−0.115	−0.110	−0.079	−0.076
		(0.125)	(0.124)	(0.124)	(0.126)	(0.124)	(0.124)	(0.124)	(0.126)
Link Duration		0.003	−0.011	−0.022	−0.011	0.107	−0.342	−0.437	−0.391
		(0.004)	(0.022)	(0.017)	(0.024)	(0.096)	(0.507)	(0.432)	(0.589)
Supplier Size (employees, in thousands)		−0.007**	−0.007***	−0.008***	−0.007**	−0.007**	−0.008**	−0.008***	−0.007**
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
First-Tier Supplier		0.031	0.007	0.001	0.036	0.020	−0.000	0.016	0.054
		(0.146)	(0.156)	(0.154)	(0.146)	(0.144)	(0.155)	(0.153)	(0.145)
Intercept		0.285	0.688	1.11*	0.808	0.029	1.48	2.53*	1.78
		(0.382)	(0.842)	(0.720)	(0.933)	(0.472)	(1.77)	(1.54)	(2.07)
Adjusted R^2		0.500	0.499	0.508	0.501	0.503	0.502	0.516	0.509

Standard errors are in parentheses.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$ (one-tailed)

derivative of the equation with respect to Technology Transfer:

$$\partial(\text{Supplier Performance Improvement})/\partial(\text{Technology Transfer}) = -0.315 + 0.245^{*}\ln(\text{Link Duration})$$

This effect is negative if Link Duration is very low. It becomes positive if Link Duration exceeds 3–4 years.[9] Interestingly, this is the typical length of a car design and component purchasing cycle in Japan (Clark and Fujimoto, 1991). All but three observations in the sample clearly exceed that threshold. Still, extrapolating the result suggests the same challenge for new relationships as in the United States: relying on technology transfer too early may not be beneficial, even though it is desirable in longer-established links.

The main effect of Link Duration is not significant, but three control variables have significant effects throughout Table 4, generating a higher adjusted R^2 (0.499–0.516). Consistent with previous research, they show that Japanese firms are particularly adept at leveraging the buyer's knowledge of the supplier's performance and at harnessing the supplier's technical influence (Asanuma, 1985; McMillan, 1990; Clark and Fujimoto, 1991). Both variables are highly correlated with the criterion and predictors, as expected. However, the main results reported above are robust to the inclusion (or exclusion) of these controls. Meanwhile supplier size has a negative effect. A possible explanation is that economies of scale are negated by organizational inefficiencies in large Japanese firms.

In summary, the results for the Japanese sample support Hypothesis 4. They do not support Hypothesis 2 once the interaction term is included. The hypotheses about simple technical exchanges are not supported. The main finding is that technology transfer can have a positive impact on supplier performance improvement, and this effect is contingent on the prior duration of the underlying buyer–supplier relationship. Vertical relationships in Japan appear to be particularly beneficial if technology flows in a well-settled interface (see also Branstetter, 2000).

DISCUSSION

Implications and comparisons of the results

The analysis provides some important results that are similar between the two samples, together with some relevant differences. The most similar results pertain to the significance and direction of the interaction effects. First, link duration does not moderate the effects of technical exchanges. The interaction is positive as expected (absent the other hypothesized interaction) but not significant. Second, and more important yet, the effect of technology transfer increases with link duration, as per Hypothesis 4. Technology transfer becomes beneficial if the buyer and supplier have interacted long enough. This implies that firms with longer-established relationships are better able to share their technology and harness their partner's.[10] A relevant feature of these results is that they pertain to supplier performance, whereas past research has tended to focus on buyer performance.

The pattern of these results is broadly consistent with Asanuma's (1985, 1989) arguments whereby buyers should initiate supplier relationships with relatively simple tasks, and subsequently undertake more ambitious joint or delegated projects as the relationship matures. This argument has been generalized outside Japan based on Japanese assemblers' behavior (Nishiguchi, 1994; MacDuffie and Helper, 1997; Dyer and Nobeoka, 2000). Our results suggest that some substantive differences should nevertheless be taken into account when

[9] Setting the derivative to 0 and solving, ln(Link Duration) = 0.315/0.245 = 1.29, so Link Duration = $e^{1.29}$ = 3.6 years. Thus, other factors being held constant, the effect of technology transfer on supplier performance improvement is estimated to become positive once the buyer–supplier relationship has lasted 3.6 years in Japan.

[10] Another way to examine the data is to ask at what link durations the above-described derivatives, representing the 'simple regression lines' between Supplier Performance Improvement and Technology Transfer, become significantly different from 0 (Aiken and West, 1991). Asking this different question, and computing a standard error conditional on Link Duration (see Aiken and West, 1991), we find that the overall effect of Technology Transfer on Supplier Performance Improvement exceeds 0 significantly (at $p < 0.05$) when Link Duration is greater than 16 years for the United States. The equivalent threshold for Japan is 9 years. Direct comparisons between the United States and Japan are not possible due to differences in sample size and unexplained variance, but both numbers suggest that it takes substantial prior link duration for technology transfer to make a strong (and positive) difference to supplier performance.

generalizing and implementing this recommendation.[11] Our findings can help explain why U.S. firms appear more willing to deal with new partners, while Japanese firms have been more reluctant to change partners.

In the U.S. sample, there is evidence that smaller-scale technical exchanges promote supplier performance improvement. Furthermore, the U.S. model with the link duration variable untransformed fits the data slightly better than when link duration is log-transformed, while the reverse is true for the Japanese data. This suggests that the distinction between medium- and long-duration links is more relevant in the United States than in Japan, where the primary distinction is between short links and longer links. However, no significant effect of technical exchanges is found in Japan. The pattern of results for Japan suggests that immediate pay-off from technical exchanges may be elusive (relative to Japanese competition), while technology transfer is most beneficial once the sourcing relationship has been in place for a moderate period. Thus, failing to reconduct a relationship past the first purchasing cycle—or after subsequent cycles—entails a substantial opportunity cost. This may explain why Japanese buyers have long been described as comparatively reluctant to change suppliers (and vice versa).

What explains that technical exchanges pay off in the U.S. sample but not in the Japanese sample? While it is theoretically possible that U.S. firms are inherently more efficient at sharing such explicit knowledge (see Hall and Hall, 1990), prior research on the automotive industry does not support this view (e.g., Liker *et al.*, 1996). A more plausible explanation is that U.S. buyers and suppliers have recently increased their commitment to joint problem solving (Helper and Sako, 1995). It is therefore comparatively easy to find technical exchange opportunities that enhance performance in the United States, whereas that is more difficult in Japan where the practice has long been exploited extensively. In both samples, meanwhile, the benefits of technology transfer remain contingent on prior link duration. Consistent with our interpretation, t-tests show that Japanese firms, whose links have been in place longer on average ($p < 0.01$), also tend to engage in more technology transfer ($p < 0.01$). U.S. firms are slightly more prone to use technical exchanges, but the difference between samples is not statistically significant. This pattern may explain why supplier turnover has generally been higher in the United States, but also why U.S. buyers have shown great loyalty to selected suppliers (Helper, 1991b). Overall, this clarifies how U.S. firms have come to expect and perhaps should still use more flexibility in partner selection, but also shows that they should not ignore the benefits of long-term relationships.

A further difference pertains to the time that it takes for technology transfer to start paying off. This takes longer in the United States than in Japan (5.1 years vs. 3.6 years, different at $p < 0.01$). While modest in absolute, this gap indicates a difference in the initial incentives to foster long-lasting relationships. Our findings may also help explain differences in the propensity to rely on extensive technology transfer. Having experienced higher turnover in the decades leading to the 1990s, though not previously (Helper, 1991b), U.S. links are more recent on average but also consist of some very old ties (up to 92 years). The fact that many U.S. suppliers with shorter-lasting relationships expect little benefits from technology transfer plausibly helps account for the difference in technology transfer emphases between the two countries. Indeed, when both samples are split according to the median U.S. link duration, the difference between countries is less among cases with longer-established links (0.342, $p < 0.10$ by the t-test) than among more recent links (0.412, $p < 0.01$).

Technical exchanges may offer early benefits for U.S. firms, and should thus be encouraged. However, given the contingent benefits of technology transfer, a challenge is to make high-level technology transfer succeed in recent relationships. Our results suggest that U.S. firms adopting aggressive technology transfer practices prematurely are likely to find these efforts ineffective.

In Japan, meanwhile, buyer–supplier links have started to fray in recent years. Relationships may now turn over faster, even for strong assemblers like Toyota (e.g., Ahmadjian and Lincoln, 2001). Thus, a challenge would again be to fructify recent links. While technology transfer starts paying off sooner, engaging in technology transfer too early is also problematic. Furthermore, our results show that small-scale technical exchanges

[11] Our discussion focuses on the hypothesized effects, but differences regarding control variables are also noteworthy.

do not improve performance relative to established Japanese competition. This suggests a transition challenge when partners are replaced. The resulting trade-off may explain the relative rigidity of Japanese buyer–supplier links. Unless relaxed, such rigidity could hinder adaptation in the face of global competition, radical technological change, or simply slower growth (Tezuka, 1997; Robinson and Martin, 1997).

Given our findings, it is worth asking whether there is a joint effect of technical exchanges and technology transfer. Even if technical exchanges have no main effect, can they complement higher-level technology transfer, and if so how? To explore this issue, we examined their interaction pairwise, as well as their three-way interaction with link duration. We found the new interactions statistically insignificant, and our other results robust. Thus, the effect of technology transfer does not appear contingent on simultaneous technical exchanges (and reciprocally). While incomplete, this additional analysis suggests that intense technical exchanges would not suffice to make technology transfer beneficial in short-duration relationships. We believe, rather, that sufficient time would need to elapse for relation-specific assets to take hold. Technical exchanges may nevertheless play a useful role for their own benefits (evidenced in the United States), and as a means of sustaining a relationship while relation-specific assets build up (see Steensma and Lyles, 2000). Undertaking technical exchanges may thus be valuable in helping relation-specific assets accumulate over time, knowing that the relation-specific assets are subsequently critical for beneficial technology transfer. The procedures deployed and adjusted by Honda to transfer best practices to U.S. suppliers (MacDuffie and Helper, 1997) are consistent with this view.

On building up relation-specific assets

For U.S. and Japanese firms alike, then, a key challenge is how to build up relational assets to render technology transfer effective. We suggest two plausible approaches to complement the passage of time. One solution may be to focus on accelerating the idiosyncratic learning process whereby buyer and supplier develop joint understanding and routines. A known way to accelerate learning through communication, the type of process that generates relation-specific assets, is to add feedback and make the information flow bilateral (Arrow, 1974; Sengupta and Abdel-Hamid, 1993).

In this respect, studies of best practices often focus on the buyer's role as source of knowledge, while paying less attention to the supplier's function other than as a recipient. Yet our survey shows some tentative evidence that firms rely on bilateral knowledge flows. One of the items loading onto Technical Exchanges pertains to bilateral communications, and items loading onto Technology Transfer include questions about technology passing from the supplier to the buyer as well as in the reverse direction (see the Appendix). While we cannot statistically separate items describing unilateral and bilateral knowledge flows in our data, one plausible way to build up relational assets is to foster two-way communication, provided each party has sufficient competence. Future research should thus examine information flows in both directions, as well as through third partners.

Another solution is to leverage firms' capacities to transfer technology, holding link duration constant. An extensive literature discussed the challenges of transferring knowledge, especially if it is tacit and team-embodied (Godkin, 1988). In response, some research has emphasized the ability of a firm to take in knowledge from outside (e.g., Szulanski, 1996). Martin and Salomon (2002) argue that two distinct capabilities contribute to successful interfirm knowledge transfer: source transfer capacity, which pertains to a transferor's ability to transmit knowledge outward, and recipient transfer capacity, which pertains to a transferee's ability to assimilate knowledge from a willing external source. All else equal, the most successful technology transfer will accrue in pairs of firms that possess the requisite combination of source and knowledge transfer capacity. Our results suggest that link duration also matters. Extending both arguments, it presumably takes time for partners to fine-tune their transfer capacity and specialize it to each other. Furthermore, if bilateral transfer is the purpose, then each firm would need time to develop both source and recipient transfer capacity.

Our results also suggest that strong performance potential exists in very long-lived relationships. However, the extreme durability of some buyer–supplier links raises the possibility of an alternative explanation for the results. If interfirm partnerships endure in the extreme, then link duration may be confounded with firm age, which itself can be associated with superior performance (Delacroix and Swaminathan, 1991). To examine this alternative, we collected measures of the age, in years, of respondent suppliers and their buyers. We could only obtain meaningful samples for the Japanese data, where $N = 67$ for the measure of supplier age and $N = 95$ for the measure of buyer age. Any concern about confusing firm age and link duration would be strongest in the Japanese sample, where the automotive industry is younger and supplier links tend to endure longer. In this instance, neither variable was significant, and our key results were essentially unchanged. This shows that link duration moderates performance improvement independently of supplier or buyer age.

Furthermore, this supplemental analysis provides some insight into the nature of the relational assets associated with link duration. It is relevant to ask just how partner-specific relational assets are. Would skills developed in dealing with a particular partner be useful only while dealing with that partner, i.e., be strictly relation-specific, or would the skills readily apply to alternative partners, i.e., be nonrelation-specific? Our data do not allow us to conduct the most direct possible test, whereby the duration of past links with alternative partners would be used as predictors of the performance of a focal relationship. Nevertheless, we find that while supplier age is significantly correlated with focal link duration (+0.30), buyer age is not (+0.09). Using age as an (admittedly imperfect) indicator of the cumulative effect of alternative relationships, we find that it has no moderating effect on technology transfer, unlike focal link duration. This indicates that the relational assets we measure via link duration are truly relation-specific.

Other opportunities for future research

One possible shortcoming of this research is common method variance. Although the data were operationalized through self-reports measured at one time, there are several reasons to believe that our findings are not an artifact of common methods. First, one-factor tests showed no evidence of a problem. Second, key findings in the study are interaction effects. Even if respondents tended to associate successive items, common method variance is unlikely to distort interaction-based analysis (Brockner *et al.*, 1997). It is difficult for a common method artifact to explain why one interaction set is strong while another is weak. Specifically, since the terms for both interactions were measured through self-report, common methods alone cannot explain why one effect (Hypothesis 4) is statistically significant while the other (Hypothesis 3) is not. Third, the existence of effects in one sample but not the other (e.g., regarding Hypothesis 1) cannot easily be attributed to common variance. Still, we recognize the need to replicate the results with procedures not consisting of common methods. Such analyses would further enhance the external validity of those reported here.

More generally, it would be interesting to replicate this research with other measures of supplier performance, preferably objective ones like market share or financial returns. We would expect the mechanisms we described to help explain such performance outcomes too, as our measure of operational performance plausibly predicts a supplier's overall competitiveness. Indeed, our items figure among the main supplier selection criteria used by buyers (Cusumano and Takeishi, 1991; Choi and Hartley, 1996). Furthermore, managerial assessments and objective indicators are generally consistent (Venkatraman and Ramanujam, 1987), including when it comes to measuring impacts of interfirm relations (Simonin, 1997). We could not use financial or market data because many automotive suppliers are privately owned, and the two-country design would make some financial comparisons problematic. Nevertheless, in a suitable context, such replication would be worthwhile.

It would also be interesting to examine the relevance of other dimensions of buyer–supplier relationships. In particular, there may be determinants of relation-specific assets other than link duration, such as the range of products being traded (Levinthal and Myatt, 1994). Our findings about the importance of link duration justify more research on the sources of relation-specific assets.

CONCLUSION

This study examines practices that contribute to supplier performance improvement among U.S. and Japanese automotive suppliers. It addresses value-adding mechanisms that long-established interfirm partnerships can enable. Our predictions point to the relevance of knowledge transfer in general, and in particular of distinguishing between simple technical exchanges and higher-level technology transfer. They highlight the role of prior relationship duration and describe how this moderates the impact of the two types of knowledge flows. Thus, this work contributes to the study of buyer–supplier relationships, while extending prior research on relational assets.

The empirical analysis confirms that knowledge transfer can be associated with supplier performance improvement. The interaction effects that we uncover work in similar ways in the United States and Japan. The regression analyses also identify some potentially important differences between the two samples such that one should not take either country as an unambiguous basis for generalizing. These findings shed light on the conditions for any convergence between U.S. and Japanese practice. Given the accumulated difference in mean link duration (10.6 years in our sample) and the residual difference in supplier turnover, adopting a straight 'Japanese' model with extensive technological cooperation may be difficult and potentially wasteful for various U.S. firms. However, we find that some U.S. firms are already in a strong position to leverage their technologies and relation-specific assets. If supplier relationships start turning over faster in Japan, meanwhile, U.S. practice might yield useful lessons (e.g., regarding technical exchanges in recent relationships). Thus, convergence toward an intermediate or third model could occur more quickly.

Regardless of the context, two major lessons follow from our findings. First, suppliers stand to benefit from systematic knowledge exchange with buyers. Second, prior link duration conditions the effectiveness of more complex, higher-level technology transfer. Most importantly, we show that higher-level technology transfer works best in long-established buyer–supplier relationships.

This confirms the importance of relation-specific assets as a source of competitive advantage (Martin *et al.*, 1998; Dyer and Singh, 1998). Altogether, this research is a step toward understanding how knowledge transfer and relational assets jointly add value between firms. Indeed, the collaborative mechanisms we describe are not unique to vertical interfirm relationships. They also stand to affect performance inside firms that integrate vertically or diversify (especially via acquisition), in horizontal technology transfer deals between rivals, and in alliances broadly defined. In each case, separate organizations must share knowledge for joint advantage to develop. This requires effective knowledge transfer mechanisms. Though governance and initial knowledge positions may vary, relation-specific assets stand to be critical in enabling the pooling of corporate capabilities. This makes link duration highly relevant in setting strategy in these contexts too. For example, merging firms should be cognizant of the state of relational assets before they implement large-scale knowledge transfers as part of their integration plans. Generally, relation-specific assets may precondition the search for intrafirm and interfirm synergy. Thus, research building on the present study will be well worth pursuing.

ACKNOWLEDGEMENTS

The first two authors contributed equally to this research. We are thankful for comments from Laurence Capron, Richard Caves, Fréderic Dalsace, Witold Henisz, Paul Ingram, Patrick Moreton, and J. Myles Shaver. The paper benefited greatly from the insights of the reviewers and the Associate Editor. Any remaining errors are ours. This research was supported by a grant from the U.S. Air Force's Japan Industry and Management of Technology Program and by a grant from the Tenneco Fund Program at the Stern School of Business of New York University. The authors acknowledge the support of the University of Texas at Austin, Columbia University, and the Mitsubishi Research Institute, where they respectively conducted a portion of this research.

REFERENCES

Ahmadjian CL, Lincoln JR. 2001. Keiretsu, governance, and learning: case studies in change from the Japanese automotive industry. *Organization Science* **12**(6): 683–701.

Aiken LS, West SG. 1991. *Multiple Regression: Testing and Interpreting Interactions*. Sage: Newbury Park, CA.

Armstrong JS, Overton T. 1977. Estimating nonresponse bias in mail surveys. *Journal of Marketing Research* **14**(August): 396–402.

Arora A, Gambardella A. 1994. Evaluating technological information and utilizing it. *Journal of Economic Behavior and Organization* **24**: 91–114.

Arrow KJ. 1974. *The Limits of Organization*. W. W. Norton: New York.
Asanuma B. 1985. The organization of parts purchases in the Japanese automotive industry. *Japanese Economic Studies* **13**(4): 32–53.
Asanuma B. 1989. Manufacturer–supplier relationships in Japan and the concept of relation-specific skill. *Journal of the Japanese and International Economies* **3**: 1–30.
Axelrod R. 1984. *The Evolution of Cooperation*. Basic Books: New York.
Bagozzi RP, Yi Y. 1993. Multitrait–multimethod matrices in consumer research: critique and new developments. *Journal of Consumer Psychology* **2**(2): 143–170.
Bentler PM, Chou CP. 1987. Practical issues in structural equation modeling. *Sociological Methods and Research* **16**: 78–117.
Branstetter L. 2000. Vertical keiretsu and knowledge spillovers in Japanese manufacturing: an empirical assessment. *Journal of the Japanese and International Economies* **14**(2): 73–104.
Brockner JP, Siegel JP, Tyler DT, Martin C. 1997. When trust matters: the moderating effect of outcome favorability. *Administrative Science Quarterly* **42**: 558–583.
Choi TY, Hartley JL. 1996. An exploration of supplier selection practices across the supply chain. *Journal of Operations Management* **14**: 333–343.
Clark KB, Fujimoto T. 1991. *Product Development Performance*. Harvard Business School Press: Boston, MA.
Cohen J, Cohen P. 1983. *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences* (2nd edn). Erlbaum: New York.
Collis D. 1991. A resource-based analysis of global competition: the case of the bearings industry. *Strategic Management Journal*, Summer Special Issue **12**: 49–68.
Craig CS, Douglas SP. 1999. *International Marketing Research* (2nd edn). Wiley: New York.
Cusumano MA, Takeishi A. 1991. Supplier relations and management: a survey of Japanese, Japanese-transplant, and U.S. auto plants. *Strategic Management Journal* **12**(8): 563–588.
Delacroix J, Swaminathan A. 1991. Cosmetic, speculative, and adaptive organizational change in the wine industry: a longitudinal study. *Administrative Science Quarterly* **36**: 631–661.
Delios A, Henisz WJ. 2000. Japanese firms' investment strategies in emerging economies. *Academy of Management Journal* **43**(3): 305–323.
Dosi G. 1988. Sources, procedures, and microeconomic effects of innovation. *Journal of Economic Literature* **26**: 1120–1171.
Dussauge P, Hart S, Ramanantsoa B. 1992. *Strategic Technology Management*. Wiley: New York.
Dyer JH. 1996. Specialized supplier networks as a source of competitive advantage: evidence from the automotive industry. *Strategic Management Journal* **17**(4): 271–291.
Dyer JH, Cho DS, Chu W. 1998. Strategic supplier segmentation: the next 'best practice' in supply chain management. *California Management Review* **40**(2): 57–77.
Dyer JH, Chu W. 2000. The determinants of trust in supplier–automaker relationships in the U.S., Japan, and Korea. *Journal of International Business Studies* **31**(2): 259–285.
Dyer JH, Nobeoka K. 2000. Creating and managing a high performance knowledge-sharing network: the Toyota case. *Strategic Management Journal* **21**(3): 345–367.
Dyer JH, Ouchi WG. 1993. Japanese style business partnerships: giving companies a competitive edge. *Sloan Management Review* **35**(1): 51–63.
Dyer JH, Singh H. 1998. The relational view: cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review* **23**(4): 660–679.
Fichman M, Levinthal DA. 1991a. History dependence and professional relationships: ties that bind. *Research in the Sociology of Organizations* **8**: 119–153.
Fichman M, Levinthal DA. 1991b. Honeymoons and the liability of adolescence: a new perspective on duration dependence in social and organizational relationships. *Academy of Management Review* **16**(2): 442–468.
Galbraith C. 1990. Transferring core manufacturing technologies in high-technology firms. *California Management Review* **32**(Summer): 56–70.
Godkin L. 1988. Problems and practicalities of technology transfer: a survey of the literature. *International Journal of Technology Management* **3**: 587–603.
Granovetter MS. 1985. Economic action and social structure: the problem of embeddedness. *American Journal of Sociology* **91**(3): 481–510.
Granstrand O, Sjolander S. 1988. Managing innovation in multi-technology corporations. *Research Policy* **19**: 35–60.
Hall ET, Hall MR. 1990. *Understanding Cultural Differences*. Intercultural Press: Yarmouth, ME.
Heide JB, Miner A. 1992. The shadow of the future: effects of anticipated interaction and frequency of contact on buyer–seller cooperation. *Academy of Management Journal* **35**(2): 265–291.
Helfat CE. 1997. Know-how and asset complementarity and dynamic capability accumulation: the case of R&D. *Strategic Management Journal* **18**(5): 339–360.
Helper S. 1991a. How much has really changed between U.S. automakers and their suppliers? *Sloan Management Review* **15**(Summer): 15–28.
Helper S. 1991b. Strategy and irreversibility in supplier relations: the case of the U.S. automobile industry. *Business History Review* **65**(Winter): 781–824.
Helper S, Sako M. 1995. Supplier relations in Japan and the United States: are they converging? *Sloan Management Review* **36**(Spring): 77–84.
Kogut B, Zander U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science* **3**(3): 383–397.
Kogut B, Zander U. 1993. Knowledge of the firm and the evolutionary theory of the multinational

corporation. *Journal of International Business Studies* **24**: 625–645.

Kotabe M. 1998. Efficiency vs. effectiveness orientation of global sourcing strategy: a comparison of U.S. and Japanese multinational companies. *Academy of Management Executive* **12**(November): 107–119.

Lamming R. 1993. *Beyond Partnership: Strategies for Innovation and Lean Supply*. Prentice-Hall: Englewood Cliffs, NJ.

Levinthal DA, Fichman M. 1988. Dynamics of interorganizational attachments: auditor–client relationships. *Administrative Science Quarterly* **33**: 345–369.

Levinthal DA, Myatt J. 1994. Co-evolution of capabilities and industry: the evolution of mutual fund processing. *Strategic Management Journal*, Winter Special Issue **15**: 45–62.

Liker JK, Kamath RR, Wasti SN, Nagamachi M. 1996. Supplier involvement in automotive component design: are there really large U.S.–Japan differences? *Research Policy* **25**: 59–89.

MacDuffie JP, Helper S. 1997. Creating lean suppliers: diffusing lean production through the supply chain. *California Management Review* **39**(4): 118–134.

Martin X, Mitchell W, Swaminathan A. 1994. Recreating and extending buyer–supplier links following international expansion. In *Advances in Strategic Management*, Vol. 10B, Shrivastava P, Huff A, Dutton J (eds). JAI Press: Greenwich, CT; 47–72.

Martin X, Mitchell W, Swaminathan A. 1995. Recreating and extending Japanese automobile buyer–supplier links in North America. *Strategic Management Journal* **16**(8): 589–620.

Martin X, Salomon R. 2002. Knowledge transfer capacity and cooperative strategies: when should firms leverage tacit knowledge through licensing and alliances? In *Cooperative Strategies and Alliances*, Contractor FJ, Lorange P (eds). Elsevier Science: New York; 729–748.

Martin X, Swaminathan A, Mitchell W. 1998. Organizational evolution in the interorganizational environment: incentives and constraints on international expansion strategy. *Administrative Science Quarterly* **43**(3): 566–601.

McMillan J. 1990. Managing suppliers: incentive systems in Japanese and United States industry. *California Management Review* **32**(4): 38–55.

Mogavero L, Shane RS. 1982. *Technology Transfer and Innovation*. Marcel Dekker: New York.

Mudambi R, Helper S. 1998. The 'lose but adversarial' model of supplier relations in the U.S. auto industry. *Strategic Management Journal* **19**(8): 775–792.

Nanda A. 1996. Resources, capabilities, and competencies. In *Organizational Learning and Competitive Advantage*, Moingeon B, Edmondson A (eds). Sage: London; 93–120.

Nelson RR. 1991. Why do firms differ, and does it matter? *Strategic Management Journal*, Winter Special Issue **12**: 61–74.

Nelson RR, Winter SG. 1982. *An Evolutionary Theory of Economic Change*. Harvard University Press: Cambridge, MA.

Nishiguchi T. 1994. *Strategic Industrial Sourcing: The Japanese Advantage*. Oxford University Press: New York.

Podsakoff PM, Organ DW. 1986. Self-reports in organizational research: problems and prospects. *Journal of Management* **12**(4): 531–544.

Porter ME. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. Free Press: New York.

Porter ME. 1985. *Competitive Advantage: Creating and Sustaining Superior Performance*. Free Press: New York.

Ramsay J. 1996. The case against purchasing partnerships. *International Journal of Purchasing Management* **4**(32): 13–19.

Robinson P, Martin X. 1997. The Japanese economy: unpacking the Japanese economic system. *Sloan Management Review* **38**(3): 6–7.

Rosenberg N. 1982. *Inside the Black Box: Technology and Innovation*. Cambridge University Press: New York.

Sakai K. 1990. The feudal world of Japanese manufacturing. *Harvard Business Review* **68**(6): 38–49.

Sako M, Helper S. 1998. Determinants of trust in supplier relations: evidence from the automotive industry in Japan and the United States. *Journal of Economic Behavior and Organization* **34**: 387–417.

Sengupta K, Abdel-Hamid T. 1993. Alternative conceptions of feedback in dynamic decision environments: an experimental investigation. *Management Science* **39**(4): 411–428.

Simonin B. 1997. The importance of collaborative know-how: an empirical test of the learning organization. *Academy of Management Journal* **40**(5): 1150–1174.

Steenkamp JE, van Trijp HCM. 1991. The use of LISREL in validating marketing constructs. *International Journal of Marketing Research* **8**: 283–299.

Steensma HK, Lyles MA. 2000. Explaining IJV survival in a transitional economy through social exchange and knowledge-based perspectives. *Strategic Management Journal* **21**(8): 831–851.

Stigler GJ, Becker GS. 1977. De gustibus non est disputandum. *American Economic Review* **67**: 76–90.

Szulanski G. 1996. Exploring internal stickiness: impediments to the transfer of best practice within the firm. *Strategic Management Journal*, Winter Special Issue **17**: 27–43.

Takeishi A. 2001. Bridging inter- and intra-firm boundaries: management of supplier involvement in automobile product development. *Strategic Management Journal* **22**(5): 403–433.

Teece DJ. 1977. Technology transfer by multinational firms: the resource cost of transferring technological know-how. *Economic Journal* **87**: 242–261.

Tezuka H. 1997. Success as the source of failure? Competition and cooperation in the Japanese economy. *Sloan Management Review* **38**(2): 83–93.

Uzzi B. 1996. The sources and consequences of embeddedness for the economic performance of organizations: the network effect. *American Sociological Review* **61**: 674–698.

Uzzi B. 1997. Social structure and competition in interfirm networks: the paradox of embeddedness. *Administrative Science Quarterly* **42**(1): 35–67.

Uzzi B. 1999. Embeddedness in the making of financial capital: how social relations and networks benefit firms seeking financing. *American Sociological Review* **64**: 481–505.

Venkatraman N, Ramanujam V. 1987. Measurements of business economic performance: an examination of method convergence. *Journal of Management* **13**: 109–122.

von Hippel E. 1988. *The Sources of Innovation*. Oxford University Press: New York.

Wasti SN. 1999. Buyers and suppliers: different strokes for different folks. Presented at the Academy of Management Meeting, Chicago, IL.

Wernerfelt B. 1984. A resource-based view of the firm. *Strategic Management Journal* **5**(2): 171–180.

Wernerfelt B. 1985. Brand loyalty and user skills. *Journal of Economic Behavior and Organization* **6**: 381–385.

White H. 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* **48**: 817–838.

Williamson OE. 1975. *Markets and Hierarchies: Analysis and Antitrust Implications*. Free Press: New York.

Williamson OE. 1985. *The Economic Institutions of Capitalism*. Free Press: New York.

Womack JP, Jones DT, Roos D. 1990. *The Machine that Changed the World*. Rawson Associates: New York.

Zaheer A, McEvily B, Perrone V. 1998. Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. *Organization Science* **9**(2): 141–159.

APPENDIX: VARIABLE MEASUREMENT

All items in multi-item variables were measured on a 5-point Likert scale. The scale was anchored by 1—'Strongly Disagree' and 5—'Strongly Agree' unless otherwise indicated.

Variable	Measure	Cronbach's alpha
Criterion variable		
Supplier Performance Improvement	A 4-item measure: • In the last 2–3 years, we have continued to be able to improve product design performance through this partnership • In the last 2–3 years, we have continued to be able to improve process design through this partnership • In the last 2–3 years, we have continued to be able to improve product quality through this partnership • In the last 2–3 years, we have continued to reduce lead time through this partnership	0.83
Predictor variables		
Technical Exchanges	A 6-item measure: • Our engineers and sales staff have a close relationship with our partner's staff • In the development process, direction of communication is bilateral rather than unilateral • Frequent contact between our partner and our engineers is important • Through informal discussion, our partner often communicates important engineering information to us • Communication with our partner often begins to occur earlier in the development process • Informal communications often reduce lead time in the development process[a]	0.83
Technology Transfer	A 5-item measure: • We share high-level engineering capability with our partner firm • We are willing to transfer technologies to our partner firm	0.83

(*continued overleaf*)

Variable	Measure	Cronbach's alpha
	• Our partner is willing to transfer technologies to us • We rely on our partner's engineering capability • Technical support from our partner firm often helps us solve technical problems[b]	
Other variables		
Buyer's Knowledge of Supplier's Past Performance	A 4-item measure: • Our partner has a good grasp of our product-design performance • Our partner has a good grasp of our process-design performance • Our partner has a good grasp of our product-quality performance • Our partner has a good estimate of the cost of the components/products we manufacture	0.84
Supplier's Technical Influence (anchors: 1—'Our Firm Has No Influence' and 5—'Our Firm Has Complete Influence')	A 4-item measure: How much influence does your firm have on your partner with respect to each of the following activities: • Product design specifications • Manufacturing process specifications • Procurement of materials and components • Product quality control	0.74
Crucial Components	For 15 component classes, the respondents were asked to rate how crucial (1—Least Crucial to 5—Most Crucial) it is for automobile manufacturers' long-term competitiveness to possess in-house development expertise. Respondents subsequently indicated which class their components matched most closely. The ratings on the 15 components were subjected to principal components factor analysis with varimax rotation to identify underlying dimensions. Two factors were extracted. The first factor includes components such as transmission, engine/engine components, and electronic parts, for which the automobile manufacturer's in-house expertise is considered crucial. The second factor includes components such as fuel tanks, exhaust systems, and tires, which are collectively considered peripheral to the automobile manufacturer's in-house capabilities. For operational brevity, a binary variable was created to classify suppliers as either crucial components suppliers (1) or peripheral components suppliers (0)	n.a.*
Link Duration	A single-item measure, reverse-scaled relative to the year 1995: What year did your firm begin business relationships with this partner? Some analyses use the natural logarithm of this variable	n.a.*
Supplier Size	A single-item measure: Approximately how many people are employed in your firm?	n.a.*
First-Tier Supplier	1 if a first-tier supplier, 0 otherwise. First-tier supplier is a single-item measure: Our firm mostly supplies components directly to the automobile manufacturer	n.a.* n.a.*

[a] A potential issue with this item is that it mentions both a practice and an outcome. We thank an anonymous reviewer for bringing this point to our attention. To ensure that this does not change the interpretation, we replicated the results after excluding this item. The results were materially unchanged.

[b] One might wonder why this item loads onto the Technology Transfer variable. We believe that this is because the words 'problems' and 'often' tend to be associated with larger-scale, higher-stakes knowledge transfer. The results are essentially unchanged when this ambiguous item is removed.

* Indicates single-item measures to which Cronbach's alpha is not applicable.