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Technology-Based New Product Development Partnerships*

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ABSTRACT

Hypotheses were developed to capture the dynamic capabilities that result from interfirm partnerships during the joint new product development (NPD) process—the ability to build, integrate, and reconfigure existing resources to adapt to rapidly changing environments. These capabilities, in turn, were proposed to have a positive impact on NPD performance outcomes: (a) proportion of new product success and (b) superior new product commercialization. In contexts where the locus of innovation is rapidly changing, the impact of interfirm NPD dynamic capabilities was hypothesized to be diminished in high-technology contexts, especially for buyers (original equipment manufacturers) and to a lesser extent for suppliers. Still, technology-based interfirm NPD partnerships were predicted to ultimately outperform low-technology ones in both NPD performance outcomes. Finally, information technology (IT) support for NPD was hypothesized to influence the interfirm NPD partnership’s dynamic capabilities. Using survey data from 72 auto company managers and their suppliers, the proposed model in which IT support for NPD influences the success of interfirm NPD partnerships through the mediating role of interfirm NPD partnership dynamic capabilities in high- and low-technology contexts was generally supported. The results shed light on the nature of technology-based interfirm NPD partnerships and have implications for their success. Theoretical and managerial implications are discussed.


INTRODUCTION

New product development (NPD) is a key source of competitive advantage for individual firms (Verona, 1999), and it is also becoming a competitive strategy
for interfirm NPD partnerships (e.g., De Boer, Van de Bosch, & Volberda, 1999; Sivadas & Dwyer, 2000). Evidence from the academic and practitioner literature suggests that interfirm NPD partnerships are becoming more successful and thereby more popular. Handfield, Ragatz, Petersen, and Monczka (1999) reported that NPD projects are significantly enhanced by supplier involvement, especially early in their life cycle. Bensaou and Venkatraman (1995) stressed the potential of interfirm NPD partnerships on product success and firm profitability. In reporting on a case study of Unisys, Balasubramanian and Baumgardner (2004) found that early supplier involvement is critical to NPD success. However, the academic literature on interfirm NPD partnerships is scarce. Because interfirm NPD partnerships deserve a unique investigation in their own right, this study focuses on interfirm NPD partnerships and the contingencies required for their success.

The trend toward interfirm NPD partnerships is boosted by increased research and development (R&D) outsourcing. Roberts (2001) reports that North American and European firms are now outsourcing about 30% of their R&D budgets in other world regions. Even if Japanese firms lag behind this pace, they still outsource a sizeable portion of their R&D budgets globally. Ettlie and Sethuraman (2002) find the R&D ratio (R&D spending over sales) to be significantly related to global sourcing. Given these trends, it is not surprising that the issue of outsourcing R&D technology has emerged as a key concern in the automobile industry (Calabrese, 2002). In fact, it may be that technology outsourcing acumen is becoming a core organizational competence in its own right. For example, D’Aveni and Ravenscraft (1994) report that vertical integration of NPD efforts increases R&D costs in 12 distinct industries.

Interfirm NPD partnerships proliferate largely because firms often cannot undertake NPD initiatives alone, especially when new technology is involved. The NPD literature and practitioner interest in interfirm NPD partnerships continues unabated, but most of the literature has not specifically examined the technology context that surrounds interfirm NPD partnerships. Scarce but emerging literature suggests that the technology context has a major influence on interfirm NPD partnerships (e.g., Brownlie, 1987; Jennings, 2002; Beth, Burt, & Copacino, 2003). Nonetheless, the academic insight and management practices needed to successfully integrate and balance the use of new technology are still in their infancy (i.e., McDermott & Handfield, 2000; Soderquist, Chanaron, & Birchall, 2001; Kimzey & Kurokawa, 2002). The interest of the popular press in innovation and high technology is increasing (August 1, 2005 Special Issue of Business Week); yet there is still relatively little rigorous research that can meaningfully improve managerial decision making in technology-based NPD partnerships, especially with regard to new products that require significant technology investments of suppliers or buyers (original equipment manufacturers [OEMs]).

Notable exceptions include the theory-based empirical study by Koufteros, Vonderembse, and Jayaram (2005). The authors studied primarily small firms (most firms in their sample of 244 discrete parts manufacturing companies had between 100 and 500 employees), showing that internal and external integration for NPD were significantly related. Also, higher levels of concurrent engineering were associated with higher levels of customer integration. Despite being statistically
significant, weak associations were shown between concurrent engineering and supplier product integration (extent to which suppliers carry out product engineering for customers) and between supplier process integration (suppliers and customer engineers jointly designing new products), and it is not clear if this was due to the small size of firms involved in the sample or some other plausible rival hypothesis.

The negative results reported by the Koufteros et al. (2005) study were just as provocative. For example, the effects of supplier integration on product innovation were significant and negative. The authors say this about the result: “What the analysis suggests is that assigning more product development responsibilities to suppliers may be having a negative effect on the ability of the organization to offer new products and features...[and] may lead to deterioration in product innovation capabilities” (Koufteros et al., 2005, p. 117). Furthermore, supplier process integration did not have a significant relationship with either product innovation or product quality. The authors go on to recommend research on the impact of the Internet and virtual technologies on these reported relationships, suggesting the potentially important role of new information technologies in interfirm NPD partnerships. The context chosen for the current study did follow this advice, because the auto industry was (and is) in the throws of this deployment process, primarily as a means of cutting costs.

The idea that new products are jointly developed by suppliers and customers is not really new and has a rich research history (e.g., Ettlie & Stoll, 1990; Ettlie, 1995; Adler, Mandelbaum, Nguyen, & Schwerer, 1996). In particular, the notion that capabilities of two firms could overlap and some capabilities would actually be duplicated in order to promote learning, coordination, and integration is well known in both academic and practitioner circles (e.g., Dyer & Singh, 1998; Joglekar, Yassine, Eppinger, & Whitney, 2001). Therefore, this study focuses on the nature of interfirm partnerships to promote interfirm capabilities such as learning, coordination, and integration, and the potential of these capabilities in the success of technology-based interfirm NPD partnerships.

More specifically, to shed light on technology-based interfirm NPD partnerships, this study examines the impact of the technology context on the partnership’s dynamic capabilities and their performance outcomes. Applied to interfirm NPD partnerships, dynamic capabilities are defined as the interfirm NPD partnership’s ability to build, integrate, and reconfigure existing resources to adapt to rapidly changing environments (Eisenhardt & Martin, 2000). Following Teece, Pisano, and Shuen (1997), dynamic capabilities are proposed to be akin to the processes of learning, coordination, and integration needed to adapt to turbulent environments.

In terms of performance, interfirm NPD performance outcomes are captured as the proportion of new products bringing commercial success (return on the original investment) and the commercialization of new products (internal rate of return relative to the competition). Moreover, this study explores the moderating role of partnership status (supplier versus buyer) on the impact of the technology context on interfirm NPD partnership dynamic capabilities. Finally, the potential impact of information technology (IT) support for NPD on the interfirm partnership’s dynamic capabilities is also examined.
The resulting structural model that predicts the performance outcomes of interfirm NPD partnerships is tested with survey and case-study data from the auto industry from both suppliers and buyers (OEMs). The results suggest that interfirm NPD partnership dynamic capabilities significantly influence both NPD performance outcomes—commercial product successes and superior product commercialization. There is a negative impact of high-technology context on NPD partnership dynamic capabilities, which is exacerbated for customers and, to a lesser extent, suppliers. Nonetheless, high-technology firms ultimately outperform low-technology firms on both performance outcomes. Finally, IT support for NPD significantly enhances interfirm NPD partnership capabilities.

The following sections justify the proposed hypotheses and present the research methodology and results, concluding with a discussion of the study's results.

CONCEPTUAL DEVELOPMENT

The proposed structural model is presented in Figure 1, and the proposed research hypotheses are justified below.

**Interfirm NPD Partnership Dynamic Capabilities and NPD Partnership Success**

Perhaps the most important part of the literature on interfirm relationships focuses on interfirm capabilities (Dyer & Singh, 1998). Conscious planning to reduce transaction costs and decisions on new technologies has an impact on the partnership’s capabilities and success. Closer integration, more effective and responsive partnerships, like those made famous by Toyota and Japanese firms in general (Oliver & Delbridge, 2002), tend to pay off, handsomely. Firms that build capabilities to manage their external partnerships have been shown to be better performers when lowering transaction costs (Dyer, 1997), enhancing the flexibility of their partnerships (Teece et al., 1997), and reducing their dependency on the environment (Finkelstein, 1997). Following this literature stream, the current focus of this research is on interfirm NPD partnership dynamic capabilities, which have been formally defined by Teece et al. (1997) as “the ability to integrate, build,
and reconfigure internal and external competencies to address rapidly-changing environments" (p. 517).

The role of dynamic capabilities is the transformation of existing resources into new functional competencies that better match the environment (Eisenhardt & Martin, 2000). In fact, Teece et al. (1997) proposed the term dynamic to reflect "the capacity to renew competences so as to achieve congruence with the changing business environment" (p. 515). For example, dynamic capabilities enabled Hewlett-Packard to transform its existing NPD competencies in manufacturing outdated plotters into building small printers that better served customer needs.

In order to identify the core processes that constitute the nature of dynamic capabilities, reference was made to Teece et al. (1997), who formally proposed three distinct organizing processes—coordinating/integrating, learning, and reconfiguring. While Teece et al. (1997) view the organizing processes of coordination/integration as a unitary process, this article proposes coordination and integration to be distinct processes, consistent with the relevant literature (e.g., Crowston & Kammerer, 1998).

First, reconfiguration describes the process of creating novel configurations of functional competencies that better adapt to the changing environment (Henderson & Cockburn, 1994). The reconfiguration process is essentially the outcome of dynamic capabilities, that is, the achievement of favorable configurations of functional competencies that match the environment. Reconfiguration is particularly relevant in NPD where new products are creative adaptations of existing ones.

Following the dynamic capabilities literature, to achieve effective reconfiguration, a set of enabling processes must be undertaken: First, learning is an essential problem-solving process that is needed to reconfigure existing functional competencies by building new knowledge (Zahra & George, 2002; Zollo & Winter, 2002). Learning is, therefore, a primary enabler of reconfiguration. Second, coordination is another key process that enables reconfiguration. Teece et al. (1997) notably argue "... [dynamic] capability is embedded in distinct ways of coordinating" (p. 519). In fact, new configurations of functional competencies require new ways of allocating resources (Helfat & Peteraf, 2003), assigning tasks (Eisenhardt & Brown, 1999), and coordinating activities (Henderson & Clark, 1990). Resource allocation, task assignment, and activity synchronization are key components of effective coordination (Crowston, 1997). Third, integrating is another fundamental component of reconfiguration because new configurations of functional competencies are "supraindividual" and require integrated patterns of interaction (Teece, 1982; Grant, 1996; Zollo & Winter, 2002). The NPD literature also emphasizes that interaction of pattern integration is necessary for new configurations of functional competencies (Iansiti & Clark, 1994). Summarizing these arguments, learning, coordinating, and integrating are the key processes that constitute dynamic capabilities by enabling the reconfiguration of existing resources into new functional competencies.

Because the effectiveness in executive organizational processes is captured by capabilities (Nelson & Winter, 1982), Pavlou and El Sawy (2006) proposed a theoretical model to capture the effectiveness in executing the processes of learning,
coordinating, and integrating with a set of corresponding capabilities: absorptive capacity, coordination capability, and collective mind. First, absorptive capacity reflects the interfirm NPD partnership’s capability to learn by identifying, assimilating, transforming, and exploiting knowledge (Cohen & Levinthal, 1990). Indeed, Zahra and George (2002) reconceptualized absorptive capacity as a dynamic capability. Second, coordination capability reflects the interfirm NPD partnership’s ability to synchronize resources and tasks to create superior new ways of performing NPD activities (Crowston, 1997). Coordination capability is a key element of an interfirm NPD partnership’s dynamic capabilities because the design of new partnership competencies depends on the effective coordination of tasks and resources (Helfat & Peteraf, 2003). For example, Lieberman and Dhawan (2005) discuss the differences of car assembly companies in their abilities to coordinate with suppliers, using Toyota as the model firm, and the impact of coordination capability on costs and quality. Third, collective mind reflects the interfirm NPD partnership’s ability to integrate disparate resources with heedful contribution, representation, and subordination into a collective system (Weick & Roberts, 1993). Collective mind is a key component of dynamic capabilities because partnerships with a more fully developed collective mind have the capacity to anticipate how to react in novel situations and reconfigure themselves (Loch & Terwiesch, 1998). On the contrary, lack of a collective mind results in slow change (Weick & Roberts, 1993). In sum, these three capabilities are proposed to capture the dynamic capabilities of interfirm NPD partnerships.

Because dynamic capabilities enhance the flexibility of interfirm NPD partnerships (Teece et al., 1997) and enable them to adapt to the changing environment (Finkelstein, 1997), it is proposed that interfirm NPD partnerships with superior dynamic capabilities will have superior new product success and superior product commercialization. The strategic potential of dynamic capabilities is reflected in achieving superior configurations of functional competencies that better match the environment (appropriate), are faster (timely), and cheaper (efficient) than competitive NPD partnerships. Interfirm NPD partnerships that learn better and faster (superior absorptive capacity) are more likely to achieve superior functional competencies (Danneels, 2002). Also, more appropriate and efficient coordination (superior coordination capability) and faster integration (superior collective mind) are more likely to enable superior configurations of new functional competencies (Weick & Roberts, 1993; Crowston, 1997). Applied to the NPD context, empirical evidence has shown that dynamic capabilities help build superior new products (Henderson & Clark, 1990) and facilitate product quality and cycle time (Iansiti & Clark, 1994). In contrast, NPD firms that were slow in shaping their functional competencies were shown to end up with rigidities (Leonard-Barton, 1992). That is, once core competencies, such as a product or knowledge database, are established, they tend to be resistant to changes in the business and technical environment and become rigidities (Leonard-Barton, 1992). Table 1, below, is introduced to show how the context chosen for testing these hypotheses is changing significantly in the locus of innovation: suppliers in the auto industry are being called on to do substantially more innovation for their assembly customers. Therefore, former core capabilities are now in flux, relative to this changing technology environment. Applied to interfirm NPD partnerships, the following hypothesis is proposed:
H1: Firms with superior interfirm NPD partnership dynamic capabilities will have more successful new products, both in terms of (i) new product success rate and (ii) superior product commercialization.

The testing of Hypothesis 1 represents a creative replication of a theme that has been in the dynamic capabilities literature for several years, applied specifically to interfirm NPD partnerships. It is important to first validate that the interfirm partnership’s dynamic capabilities impact new product success before other aspects of interfirm NPD partnerships can be explored.

High- Versus Low-Technology Interfirm NPD Partnerships
A primary focus of this study is on the underlying technology context involved in interfirm NPD partnerships—in particular, high versus low technology—and specifically, the difference it provides in terms of how firms organize and manage NPD activities with their partners. The basic premise is that high technology is not necessarily a panacea for interfirm partnerships. The technology context is more complicated and often contingent on other factors, such as industry, complexity, and history (Tatikonda & Stock, 2003). In particular, if the NPD context is changing, it strains the interfirm NPD partnerships already in place and the need for both internal and external technology sourcing alternatives (Nicholls-Nixon & Woo, 2003). Intellectual property issues are likely to color any relationship between interfirm NPD partners, but the more technology, the more complicated things become (Choi, Budny, & Wank, 2004). Therefore, the changing nature of the high-technology context is likely to negatively affect the NPD partnership’s dynamic capabilities by making it difficult to stay current with new knowledge (absorptive capacity), coordinate new activities (coordination capability), and integrate new patterns of interaction (collective mind). The following hypothesis is proposed:

H2: A higher-technology (as opposed to lower-technology) context has a negative impact on interfirm NPD partnership dynamic capabilities.

There is further justification and rationale for Hypothesis 2, and even some empirical evidence, because the relationship between a partnership’s dynamic capabilities and its performance is actually curvilinear in an inverse U-shaped outcome (Rothaermel & Deeds, 2004). As these authors describe, the more productive interfirm NPD partnerships are initially, the less productive future interfirm NPD partnerships become due to information and knowledge overload. Therefore, as firms enter into higher-technology interfirm NPD partnerships, their dynamic capabilities start suffering, as Hypothesis 2 argues. Consequently, an increase in high-technology outsourcing strains newer, higher-technology interfirm NPD partnerships by increasing the overall degree of information and knowledge overload.

The Role of Partner Status
The status of each partner (buyer versus seller) is proposed to moderate the relationship between the technology context and the interfirm NPD partnership’s dynamic capabilities. Because buyers (OEMs) tend to dominate most NPD efforts and have a leading role in interfirm NPD partnerships, the expectation is that, if there is a
need for high-technology investments, suppliers are often required by OEMs to invest in high technology (due to differences in bargaining power). Therefore, suppliers will be more at risk than buyers in ending up with obsolete NPD activities because buyers can always obtain the new technology by resorting to new suppliers who possess newer technologies. This is especially true in cases where intellectual property issues have not been properly resolved in the wake of high-technology changes. Summarizing these arguments, the following hypothesis is offered for testing:

**H3:** The relationship between the technology context and interfirm NPD partnership dynamic capabilities is moderated by partner status: The high-technology context is a more significant barrier for suppliers than for buyers in the partnership, and a negative moderating effect is anticipated for suppliers.

The rationale for Hypothesis 3 requires further elaboration and exploration because it goes against common sense. That is, most would expect that high-technology suppliers would be more capable of dealing with buyers (OEMs) than their low-technology cohorts. However, managing high-technology interfirm NPD partnerships is very complex, and it often strains such NPD partnerships. For example, in the context of the automotive industry, suppliers have taken on an increasingly greater proportion of the R&D technology for new products, and the intellectual property requirements are renegotiated in most high-technology cases. Recently, for instance, many of Ford Motor Company's suppliers would not sign a newly proposed purchasing agreement because Ford would not guarantee to keep confidential supplier trade secrets (Armstrong, 2004a). That is, intellectual property issues have finally reached such a critical point, along with payment and termination conditions, as to block the normal, long-standing interfirm NPD relationships in this industry. Also, the flux of technology locus generally strains NPD partnerships in any industry, outstripping most traditional NPD-partnership governance tools like purchasing agreements. For a more detailed review, see Rubenstein (1995) and Santoro and Saputo (2003).

Therefore, the discovery of how suppliers convert their lowered appropriation conditions to high appropriation of rents (Teece et al., 1997) is very much a part of the rationale of Hypothesis 3.

**High- Versus Low-Technology NPD Partnerships and NPD Success**

Because there is inherently higher risk for high-technology interfirm NPD partnerships, they are less likely to have as high a success rate with their new products as low-technology firms. For example, Kuk (2004) found that greater integration with suppliers improves vendor-managed inventory system performance, but that scale effects did not matter—that is, larger firms that were expected to have more resources for technology adoption did not outperform smaller firms.

On the other hand, high-technology firms need to achieve greater profits in order to support higher investments in R&D. Hence, the performance of partners in interfirm NPD partnerships varies by the measure of the technology context. For example, in the automotive industry, suppliers spending more on technology also
report higher profit margins (Armstrong, 2004b). Therefore, the following two-part hypothesis is offered for testing:

\[ H4: \text{A higher-technology (as opposed to a lower-technology) context has:} \]
\[ (i) \text{a positive impact on new product success rate and} \]
\[ (ii) \text{a negative impact on superior product commercialization.} \]

The rationale for Hypothesis 4 is simple, in spite of the complex nature of the causality. High-technology firms, especially suppliers, are likely to be encouraged to invest most of their innovation sources in NPD (Teece et al., 1997). For example, Ettlie and Sethuraman (2002) found that the percentage of revenue from new products was significantly related to standard measures of total quality (e.g., Kaizen manufacturing programs). This suggests that product quality and new product revenues are positively related. However, this same quality index was inversely and significantly related to the R&D technology intensity of firms. This suggests that newer, higher-technology products typically have quality issues, and they may thus have more commercialization problems. This complements the findings of Koufteros et al. (2005) who reported that supplier integration actually lowered product innovation.

Moreover, there must be resources for technology investments, and profits are the source for these investments. However, high-technology products are risky (and their hit rates are thus lower) and the outcomes of building dynamic capabilities will depend on which NPD performance measures are used. Therefore, high-technology products may result in higher new-product success rates, but they may also result in lower commercialization rates.

**IT Support for NPD and Interfirm NPD Partnership Dynamic Capabilities**

What makes the addition of the technology context interesting for this study is that it simultaneously introduces two important variables into interfirm NPD partnerships: (i) the technologies of strong appropriation conditions, such as R&D technology invested in new products and processes (which can typically be protected with intellectual property rights), and (ii) technologies of weak appropriation that are typically purchased from outside, such as new IT technologies to help build and deliver new products. Teece et al. (1997) also allow for intermediate appropriation conditions without specification, suggesting that partners share the labor and fruits of the interfirm NPD partnership. This allows for IT tools to enter into interfirm NPD partnerships.

The literature on establishing close interfirm NPD partnerships and integrated ties between suppliers and buyers generally agrees that IT is a very important enabler in efforts to improve NPD partnerships (Pavlou & El Sawy, in press). Sharing information and processes has been shown to be instrumental as an underpinning for interfirm NPD partnerships (Shore, 2001). The more technology is involved, the more IT is required (Ellram & Zsidisin, 2002).

As with most interfirm processes, dynamic capabilities can also be enhanced by IT. Indeed, there is a recent emphasis on facilitating dynamic capabilities by effectively using IT (e.g., Hitt, Keats, & DeMarie, 1998; Wheeler, 2002; Sambamurthy, Bharadwaj, & Grover, 2003; Pavlou & El Sawy, in press). Applied
to NPD, it is necessary to formally hypothesize the role of IT support for NPD as an antecedent of interfirm NPD partnership dynamic capabilities, drawing upon the logic that IT can facilitate information and knowledge intensive processes.

IT support for NPD is defined as the extent to which the IT function upholds the efforts of the interfirm NPD partnership, and it includes the skills and capabilities of the IT function, the collaboration between NPD and the IT function, and whether the principles and values of the IT function are similar to those of the NPD unit.

Because dynamic capabilities are information-intensive routines (Zollo & Winter, 2002), they can first leverage IT to better process information. Second, dynamic capabilities have also been conceptualized as knowledge-intensive processes (Helfat & Raubitschek, 2000). As such, their efficiency, scope, and flexibility (Grant, 1996) can be facilitated by adequate IT support. Indeed, IT can enable rapid, accurate, and reliable knowledge sharing (Alavi & Leidner, 2001); it can increase knowledge reach and richness (Sambamurthy et al., 2003); it can decrease ambiguity (Terwiesch, Loch, & DeMeyer, 2002); and it can also increase the accessibility and availability of new knowledge (Zahra & George, 2002). IT support for NPD can thus enhance dynamic capabilities through superior information processing and knowledge management. Applied to interfirm NPD partnerships, IT support for NPD is proposed to facilitate interfirm NPD partnership dynamic capabilities, as formally hypothesized below:

\[ H5: \text{Firms (suppliers or buyers) that have superior IT support for NPD are more likely to have superior interfirm NPD partnership dynamic capabilities.} \]

RESEARCH METHODOLOGY

The first data collection phase began with five in-depth case studies of firms chosen for their known, recent experience with interfirm NPD partnerships. These firms represented a diverse set of industries, such as eye care, automotive and truck assembly, film and chemicals, and contract plastic-mold and prototype manufacturing. Over a dozen managers and IT support people in these five firms reported on two complete demonstrations of partnership NPD systems in order to begin developing survey and interview protocols.

It took several months to gain access and then to complete these five preliminary cases, even in firms where long-standing, sound relationships existed with research staff. In consulting with colleagues who were also in the field at that time, it was found that negotiation of entrée to study radical NPD innovation might take as long as 1 year, and this was simply too long for this study plan. One research team completed a total of only 12 cases in 1 year on their radical innovation projects (O'Connor & DeMartino, in press). With challenges looming for entrée to firms on this sensitive topic, the study proceeded directly to the next stage: a mail survey with interview follow-ups in the automotive industry to avoid these difficulties.

The automotive industry was chosen for two important reasons. First, the industry is driven by complex new product introductions. Second, there is a trend toward changing the locus of innovation in this sector of the economy, moving
upstream in the supply chain from assembly (buyer) firms like General Motors Corporation and Toyota to first-tier suppliers like Delphi and Visteon. Archival data also support this generally accepted trend as reported in the trade press. For example, in the existing archival data available on R&D investments in two large subsectors of this industry (SIC 3714, n = 39 automotive parts firms versus SIC 3711, n = 23 bodies and assembly firms) over the period 1993–2002, the approximate industry averages in R&D intensity (percentage of annual sales spent on R&D) are listed in Table 1.

R&D intensity data for 1993–1997 are from Schonfeld & Associates, Research & Development Growth Trends: Inflation Adjusted Analysis of R&D Spending, Riverwoods, IL, 1998, 136–140 & 330. Data for 2002 are from Schonfeld & Associates, R&D Ratios and Budgets, Evanston, IL, 2002. As one can see from these trends, the major auto suppliers have caught up to and surpassed their original equipment assembly buyers in R&D intensity.

**Preliminary Findings from the Pilot Case Studies**

Results compiled from pilot interviews in these five firms were very helpful in designing the survey instrument (see Appendix A). In particular, real evidence of cycle-time reduction without quality tradeoffs was found (Sobrero & Roberts, 2001), which has been the bane of manufacturers, especially in the durable goods industry. Further, the emergence of two technology cores, or thought worlds—the information world of hardware/software/network systems in need of standardization—and the core business technology of products and services, seemed critical in this context, validating proposed conceptual distinctions.

A mailed survey using a five-page questionnaire was completed in the automotive industry, representing final assemblers and first-tier automotive suppliers. This resulted in a representative sample (n = 72) of respondents from 60 firms, with follow-up interviews for representative firms, as discussed below.

**Survey Data Collection Procedure**

The survey data were collected July–November 2002 in the automotive industry, that is, primarily first-tier suppliers and their assembly customers. The surveys were completed primarily by the designated managers involved in interfirn NPD partnerships. The single largest category of respondents was manager (middle), with 32 (44%) respondents indicating that job title. Next in frequency rank was

<table>
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<th>Year</th>
<th>Auto Parts (SIC 3174) (%)</th>
<th>Auto Assemblers (SIC 3711) (%)</th>
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<td>2.2</td>
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<tr>
<td>2002</td>
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director, with 12 (16.7%), and then senior manager with 10 (13.9%) of the total sample. Taken together, the majority of respondents were firm managers at either senior or middle levels with a total of 54 (75%) in this sample of 72 automotive companies. The remaining 25% comprised design leaders, engineers, or safety personnel.

While the usable response rate was 2.025% (72 of 3,554), the effective response rate was determined to be 9.2% by using call-back data with nonrespondents. Only 21% (50 of 238) of firms reached in call backs were eligible, such as those being directly involved in NPD. This resulted in an effective response rate of 9.2% (188 ineligible/238 = .79; 1 − .79 = .21; (72/3,742) × .21 = 9.2%), which is lower than usual, so comparisons were made between the Hoover’s (2006) archive compiled on the Fortune 1000 firms and the sample. A random sample comparison of nonrespondent firms on the mailing list with respondent firms using these archival data on both sets of firms (two independent sample t-tests), resulted in no differences in sales ($t = 1.66, N/S), sales growth ($t = 1.67, N/S), employees ($t = 1.66, N/S), R&D expenditure ($t = 1.72, N/S), ROE ($t = 1.72, N/S), and current ratio ($t = 1.70, N/S).

ROE is defined as “the accounting ratio which measures net income to common equity. The ratio tells how well investors are doing in an accounting sense” (Brigham & Ehrhardt, 2002, p.86). Current Ratio “provides the best single indicator of the extent to which the claims of the short-term creditors are covered by assets that are expected to be converted to cash fairly quickly. It is the most commonly used measure of short-term solvency and is calculated as current assets divided by current liabilities” (Brigham & Ehrhardt, 2002, p. 76). R&D Expenditure was entered into the analysis as reported by Hoovers (2006). The dollar value that the firm spent on R&D for 2002 was recorded. Sales was an absolute dollar value from 2002 and sales growth was determined as the percent change in reported total sales from the previous years reports (both values from Hoover’s Online, 2006). It was concluded that response bias was minimal, and that this sample is representative of the population of automotive firms involved in interfirm NPD partnerships.

Four weeks after surveys were mailed, calls were made to survey recipients in the top 150 auto supply firms (as reported by Automotive News, March 24, 2003). This effort was intended to increase the response rate among top firms in the automotive industry that were most likely to be engaged in interfirm NPD partnerships. Telephone calls also helped in identifying ineligible respondents (e.g., not involved in NPD, retired, deceased, etc.).

Firm size was taken from the archive when firm names were known and public data were available. The resulting descriptive statistics for sales and number of employees are given below. In 2002 the average number of employees in the complete data cases ($n = 69$) was 160,081 (median was 63,000), with average sales of $60 billion (median was $10.6 billion). These numbers reflect large companies.

Development of Measures
The measurement items for the study’s principal constructs are based on existing or newly developed scales that were adapted for the study’s context, as shown in
Appendix A. The preliminary instrument was pilot tested for face validity, comprehensiveness, and clarity by an expert panel of experienced academics and NPD practitioners, following Churchill (1979).

**Interfirm NPD partnership dynamic capabilities**
The measure of *interfirm NPD partnership dynamic capabilities* was developed based on Pavlou and El Sawy (2006a) with a 12-item Likert-type scale, anchored at 1 = much worse, 3 = same, and 5 = much better, relative to competitors. Higher scores indicate the self-reported perception of a better capability of dealing with NPD partners as compared with the competition. Given that the construct of dynamic capabilities is unidimensional (Pavlou & El Sawy, in press), the three underlying factors (absorptive capacity, coordination capability, and collective mind) are modeled with a formative higher-order model (Figure 2). A formative model is appropriate because the implementation of dynamic capabilities is consequential (Eisenhardt & Martin, 2000), and the first-order capabilities (absorptive capacity, coordination capability, and collective mind) are posited to enable or form the interfirm NPD partnership dynamic capabilities. Moreover, the first-order capabilities are inherently dynamic, and a change in any first-order capability would not necessarily imply a corresponding change in the other first-order capabilities, rendering a reflective model less likely.

**Interfirm NPD partnership success**
Self-reports of *new product success rates* and *superior commercialization of new products* were used to gauge the interfirm NPD partnership success. These measures were found to compare well with published distributions for assembled products industries; reference the validation discussion in Etlinie (1997, 2000). A new product success rate of 60% after introduction is typical for an average. The success rate here was reported to average 60.1% (median = 70% and mode = 50%).

Respondents were asked about the outcomes of the NPD process, and to rate their “performance relative to their major competitors (on) superiority of commercialization (e.g., internal rate of return)...” This item was scored −1 for worse, 0 for neutral, and +1 for better than competitors.

**Figure 2:** The formative model of interfirm NPD partnership dynamic capabilities.
Respondents were also asked what percentage of their products introduced into the market in the last 5 years were successful (some multiple of return on investment), and also the percentage that were successful in terms of profitability. The zero-order correlation between the NPD partner scale and profitability was $r = .184$ ($p = .16$) two-tailed test (N/S), and it was excluded from the correlation matrix in Table 2.

The new product commercialization success rate (reported here previously) was validated by evaluating all firms that are publicly held in Hoovers (2006) (http://premium.hoovers.com/subscribe/). Using the most recent sales and previous base year, the net change in sales was calculated (average was +4.6% for this sample) in a regression model (see Ettlie, 1997 for the precedent of this technique). Net-sales change was taken as dependent, new product commercialization success percentage as the predictor, and base (previous) year as the control. The correlation for net-sales change and new product success rate was $r = .318$ ($p = .033$, $n = 45$ complete data cases). When this relationship is controlled in the regression by base year sales, the values of $r = .316$ ($p = .031$) are essentially the same. Therefore, strong evidence was found for this robust, valid measure of new product success.

**High-technology versus low-technology context**

Measures of high-technology and low-technology context, using the R&D ratio scale (R&D spending the previous year as a proportion of sales) from self-reports, were selectively checked with archival data, and no discrepancies were found. Schonfeld Associates (1998, 2002) data were used for the archival source, but these ratios can also be calculated directly from sales and archival data on R&D investments. These were all NPD projects involving some degree of computer-assisted coordination, or they would have been excluded from the sample. Furthermore, because most of the large automotive firms participated in this project, as indicated earlier, a substantial portion of the R&D spent on new products in this industry was actually represented in this sample.

**IT support for NPD**

IT support for NPD was measured with a 16-item scale, according to Ettlie and Perroli (2002) methods. Following the conceptual definition of IT support as this unit's efforts to assist interferm NPD partnership, the construct covers the dimensions of (1) IT skills and capabilities, (2) IT-engineering collaboration, and (3) IT principles and values.

**Automotive Industry Interviews**

A total of 23 on-site and telephone interviews with automotive engineering managers and IT professionals in 14 firms was conducted to enhance our understanding of high-technology interferm NPD partnerships. Of the firms that participated in the interview portion of the study, two forms of interview protocol were used: one for engineering managers (Form A) and one for IT professionals (Form B). A total of 12 engineering managers completed Form A, and 11 IT professionals completed
Form B. Of the 23 respondents, six were OEMs and 17 were automotive suppliers. Interviews were conducted from March 2003 through May 2003.

The interview schedule was designed so that approximately 75% of the interviews would result in the same protocols as the mailed surveys (for comparative purposes). The interviews differed in one important aspect in the sense that a modified critical incident technique was used, following Dutton, Ashford, O’Neill, and Lawrence (2001). This avenue for protocol development was particularly appealing because of the recent trend toward less traditional self-report data gathering illustrated in organizational behavior by Dutton et al. (2001) and related disciplines. Zaltman (2003) argues that, because 95% of human thinking occurs unconsciously, much of what we feel surfaces as metaphors. Memories are story-based, so if you ask people to tell stories, you will get a more accurate picture of their actual perceptions.

Using this modified critical incident technique, we asked respondents:

"Please think back over particular, recent incidents (past year) in which you were directly involved in attempts to improve the NPD process. We define an incident in very broad terms—that is these are typically representative occurrences of an on-going process or trends within or between firms."

Next we asked them to “Briefly describe, in an open-ended fashion (tell a story), a successful attempt on your part to positively influence the NPD process (including outcomes used to measure this success).”

Then we asked them to give us an example of an unsuccessful attempt, if they were aware of any.

The stories collected were coded by two researchers with a result of 95% agreement on story content, (whether it was tactical or strategic in change effort) and on measures (whether it was an in-process measure (e.g., saved time) or outcome measure (e.g., buyer satisfaction measure)). Furthermore, in all but a few cases, these interviews reinforced the importance of this research. All of these auto companies are challenged by the NPD process when working with partners and new IT support, such as collaborative, often Web-based, virtual team hardware/software systems.

An example of one of these cases involves a truck manufacturer engaged in the adoption and prove-out of collaborative engineering hardware-software systems designed to allow virtual team collaboration with major customers as well as across company divisions (e.g., drive train and chassis design and production). In the past, this firm had encountered an accumulation of delays in its NPD process due to travel by team members and delay of design reviews at significant gates in the NPD process. Management in this division, learning from the experience of the drive train group, insisted that key members not be bypassed by the process. If used properly, virtual engineering enables 24-hour development cycles. As a result, travel during the development process no longer had to have the effect of slowing things down. Furthermore, as the teams learned how to collaborate from afar, often around the world, most of the work that formerly was conducted during design reviews in terms of critical decisions was now done before the design review meetings. This rendered the meetings as true reviews and accelerated the process significantly with improved quality and knowledge sharing for the next product launch.
RESULTS

Partial least squares (PLS) was used to analyze both the measurement and also the structural model. PLS employs a component-based approach, and it places minimal restrictions on the sample size and residual distributions (Chin, Marcolin, & Newsted, 2003). In general, PLS is better suited for explaining complex relationships with a small data set as it avoids two major problems: inadmissible solutions and factor indeterminacy (Chin et al., 2003). Hence, PLS was chosen to account for the small sample size, the formative higher-order factor for interfirm partnership dynamic capabilities, and the moderating effects.

Measurement Validation

Reliability for the multi-item scales was assessed using both Cronbach’s alpha and the PLS internal consistency measure. For the interfirm NPD partnership dynamic capabilities construct, Cronbach’s alpha was .83 and its internal consistency score was .84. For IT support for NPD, Cronbach’s alpha was .85 and its internal consistency was .87. These values denote adequate reliability for the study’s multi-item scales.

Second, convergent and discriminant validity is inferred when the PLS indicators (i) load much higher on their own factor than on other factors, and (ii) when the square root of the Average Variance Extracted (AVE) is larger than its correlations with other scales (Chin, 1998). As shown in Table 2, all AVEs were above .90, thereby far exceeding the .70 cutoff point (Chin et al., 2003). This suggests that all AVEs are much larger than all cross-correlations to capture much higher construct-related variance than error variance.

Moreover, discriminant and convergent validity was also examined with the confirmatory factor analysis procedure in PLS. As shown in Appendix B, all items loaded well on their hypothesized constructs, which were considerably higher than all cross loadings. This excellent loading pattern suggests adequate convergent and discriminant validity (Pavlou & Gefen, 2004). This pattern also suggests unidimensionality for the multidimensional constructs of interfirm NPD partnership dynamic capabilities and IT support for NPD (Pavlou & Gefen, 2005).

Table 2: Descriptive statistics and correlation matrix of principal constructs.

<table>
<thead>
<tr>
<th></th>
<th>Mean (STD)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Interfirm NPD Partnership Dynamic Capabilities</td>
<td>3.6 (.84)</td>
<td>.91</td>
<td>.23*</td>
<td>.24*</td>
<td>-.27*</td>
<td>.27*</td>
</tr>
<tr>
<td>2. New Product Success Rate</td>
<td>60 (30)</td>
<td>1.0</td>
<td>.24*</td>
<td>-.29*</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>3. Superior Product Commercialization</td>
<td>.60 (.66)</td>
<td>1.0</td>
<td>-.11</td>
<td>.24*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. R&amp;D Ratio</td>
<td>.10 (.13)</td>
<td>1.0</td>
<td>.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. IT Support for NPD</td>
<td>2.83 (1.22)</td>
<td></td>
<td></td>
<td></td>
<td>.94</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at p < .05 level.
Average variance extracted (AVE) is shown on the diagonal in bold.
To examine the potential for common method bias, several tests were performed, following Pavlou and Gefen (2005). First, Harman's one-factor test (Podsakoff & Organ, 1986) was used. Each principal construct from the principal component factor analysis roughly explains equal variance (range = 12.9–20.7%) (total variance explained = 81.1%) (Appendix B), indicating lack of severe common method bias. Second, the correlation matrix (Table 2) does not show any exceptionally correlated variables. Third, a partial correlation method was used, following Podsakoff and Organ (1986). The highest factor from the principal component factor analysis was added as another independent variable on all dependent variables. This variable is assumed (Podsakoff & Organ, 1986, p. 536) to: “contain the best approximation of the common method variance if it’s a general factor on which all variables load.” This independent variable did not significantly increase the variance explained in any of the dependent variables, indicating no common method bias. In summary, these tests suggest that common method bias is not a serious concern in this study.

Multicollinearity was not a serious concern to the study’s validity because all relevant checks (eigenanalysis, tolerance values, variance inflation factor) did not suggest any evidence of multicollinearity. Also, no evidence of heteroscedasticity was detected. Finally, outlier analysis did not indicate extreme values.

The preceding tests jointly validate the measurement properties of the study’s constructs.

Second-Order Model of Interfirm NPD Partnership
Dynamic Capabilities

The proposed higher-order formative model of dynamic capabilities was tested with PLS, following Chin et al. (2003) and Pavlou and Gefen (2005). This procedure models the weights ($\gamma$) of the first-order factors to the second-order factor derived using a principal components factor analysis (Diamantopoulos & Winklhofer, 2001):

$$\text{Dynamic Capabilities} = \gamma_1 \times \text{Absorptive Capacity} + \gamma_2 \times \text{Coordination Capability} + \gamma_3 \times \text{Collective Mind}$$

As shown in Figure 3, the impact of all first-order capabilities on the second-order dynamic capabilities factor is significant ($p < .01$). Therefore, the construct

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**Figure 3:** Results of the formative higher-order model of dynamic capabilities.
of interfirm NPD partnership dynamic capabilities is proposed as a unitary second-order construct formed by the three proposed capabilities (absorptive capacity, coordination capability, and collective mind).

**Testing the Proposed Structural Model**

The PLS path coefficients are shown in Figure 4. The moderating effects of supply chain position (supplier versus buyer) were tested as part of the overall structural model with measures produced as interaction terms formed by cross-multiplying all standardized items of each factor (e.g., supply chain position \( \times \) R&D ratio), following the procedure of Chin et al. (2003).

As shown in Figure 4, interfirm NPD partnership dynamic capabilities have a positive impact on both dimensions of NPD partnership success, thus supporting Hypothesis 1. More specifically, the impact on new product success (\( \beta = .28, p < .05 \)) supports Hypothesis 1i, and on superior product commercialization (\( \beta = .24, p < .05 \)) validates Hypothesis 1ii. (Beta (\( \beta \)) = standardized PLS coefficients).

A higher-technology context negatively influences NPD partnership dynamic capabilities (\( \beta = -.21, p < .05 \)), thus supporting Hypothesis 2. This relationship is modestly attenuated (negatively moderated) for suppliers (\( \beta = -.13, p < .10 \)), thus partially supporting Hypothesis 3.

The higher-technology context influences both dimensions of NPD partnership success. A higher-technology context positively impacts both the new product success rate (\( \beta = .20, p < .05 \)), and also the superior product commercialization (\( \beta = .16, p < .10 \)). This supports Hypothesis 4i, but it suggests the inverse effect predicted by Hypothesis 4ii. These results seem to indicate that firms can overcome the negative impact of high technology on their interfirm NPD partnership dynamic capabilities (Hypothesis 7). This explanation is supported by the fact that Hypothesis 2 is partially supported (weak negative effect of high-technology context on dynamic capabilities). Finally, IT support for NPD has a positive impact on NPD partnership dynamic capabilities (\( \beta = .25, p < .05 \)), thus supporting Hypothesis 5.

Table 3 summarizes the hypotheses testing.

The variance explained (\( R^2 \) adjusted for degree of freedom) is 24% for new product success rate, and 20% for superior product commercialization.

A competing model was also tested in which IT support for NPD was directly linked to NPD performance (higher new product success rate and product
Table 3: List of the research hypotheses and statistical support.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1i: Superior NPD Partnership Dynamic Capabilities → Higher New Product Success Rate</td>
<td>Yes</td>
</tr>
<tr>
<td>H1ii: Superior NPD Partnership Dynamic Capabilities → Superior Product Commercialization</td>
<td>Yes</td>
</tr>
<tr>
<td>H2: Higher Technology Context → Inferior NPD Partnership Dynamic Capabilities</td>
<td>Partially</td>
</tr>
<tr>
<td>H3: Supplier Status Negatively Moderates the Technology Context → Dynamic Capabilities Relationship</td>
<td>Yes</td>
</tr>
<tr>
<td>H4i: Higher Technology Context → Higher New Product Success Rate</td>
<td>Yes</td>
</tr>
<tr>
<td>H4ii: Higher Technology Context → Inferior Product Commercialization</td>
<td>No (Reverse)</td>
</tr>
<tr>
<td>H5: Superior IT Support for NPD → Superior NPD Partnership Dynamic Capabilities</td>
<td>Yes</td>
</tr>
</tbody>
</table>

commercialization), following Baron and Kenny’s (1986) formal test for mediation. Baron and Kenny’s (1986) test for mediation compares three competing models. One competing model tested had only the hypothesized direct effects, another only the hypothesized indirect effects, and a third, integrative model had both the direct and indirect effects. Full mediation is evidenced when the indirect effects become insignificant and when the direct effects are included in the integrative model.

Despite being initially significant (when NPD partnership dynamic capabilities were excluded from the PLS model), IT support for NPD became insignificant when dynamic capabilities were included as an independent variable in the proposed model, indicating that the interfirm NPD partnership dynamic capabilities fully mediate the impact of IT support for NPD on both measures of NPD performance.

Other competing models were also tested by exploring the possibility of other links among the study’s principal constructs. However, there was no other significant relationship among any other constructs, other than the ones shown in Figure 4.

Finally, the possibility of having the reverse order of causality on all of the model’s proposed relationships was tested. PLS allows the investigation of reverse causality by comparing the variance explained on the dependent variables. The proposed model (Figure 4), with the suggested directions of causality, explains the highest variance in all of the study’s dependent variables, implying that the proposed causal directions are statistically more likely.

DISCUSSION

Key Findings

This study shows that interfirm NPD partnership dynamic capabilities are significantly related to two critical NPD success outcomes—here measured as the
proportion of new products becoming commercial successes (e.g., they return a multiple of the original investment), and superior commercialization (e.g., measured by internal rate of return compared to competitors). Also predicted and found was an inverse relationship between interfirm NPD partnership dynamic capabilities and R&D ratio, implying that high-technology relationships are clearly strained, as hypothesized. This is especially true in the auto industry due to intellectual property tensions that have increased dramatically in this industry in recent years. Further, suppliers, as opposed to buyers (OEMs), are more adversely affected by the high-technology context. Finally, IT support for NPD has a positive impact on interfirm NPD partnership dynamic capabilities.

Limitations and Suggestions for Future Research

Although the advantages of limiting innovation research to single-industry studies to control for technology characteristics are well accepted in the literature (e.g., Tushman & Anderson, 1986), and the auto industry is a rich context to explore for joint new product development, findings as important as those reported here need to be replicated elsewhere. One has to wonder if any assembled parts industry is really representative of process industries or manufacturing, generally. It also raises the issue of whether or not nonmanufacturing contexts share the same problems, challenges, and solution space as shown in this study on joint new product development. Further, in spite of the consistent statistical significance of findings, with 72 cases in 60 firms, a larger sample size would detect more subtle effects. It is likely that these results will generalize well to discrete parts, such as durable goods manufacturing, because these industries have shown to “cluster” in previous work on technological innovation (e.g., Et fille & Reza, 1992). However, future survey work on nondurable goods industries or even other nonmanufacturing sectors like service and extraction would be warranted to test external validity. There seems to be less reason to be concerned here about internal validity, because the measures line up well with previous work and reliability estimates.

One other suggestion, on the methodological front, however, does leap to mind. Given the absence of any conflicting findings from the pilot case studies that were used for framing, it suggests that in-depth case studies (e.g., Yin, 1994) might add to our knowledge of the process by which these partnerships evolve, especially in empirical contexts as in the auto industry, where the locus of innovation is changing. Perhaps aerospace, pharmaceuticals, and vertical markets of IT and homeland security (e.g., security technology) would be candidates.

One has to keep in mind, however, that entrée issues especially apply for case studies, as discussed in the Methods section.

Implications for Technology-Enabled Interfirm NPD Partnerships

What can be done to improve interfirm NPD partnerships when the technology context of new products is at stake? One way appears to be through the support of the IT function, which is found to be significantly and directly related to superior interfirm NPD partnership dynamic capabilities. This result is consistent with the increasing interest in the growing research in IT-enabled collaborative engineering and virtual teams (Sambamurthy & Zmud, 2000), especially among
partners involved in collaborative NPD projects (e.g., De Boer, Van de Bosch, & Volberda, 1999; Sobrero & Roberts, 2001; Pavlou & El Sawy, in press). This finding is also relevant for the growth of geographically dispersed NPD partnerships that can be enhanced by IT (Nambsan, 2003). Finally, the fact that IT support for NPD has a substantial positive influence on interfirm NPD partnership dynamic capabilities, suggests the need to involve the IT functions more directly in NPD partnerships.

This study demonstrates that the high-technology context moderates the relationship between the interfirm NPD partnership’s dynamic capabilities and its performance outcomes, but not exactly as predicted. While high-technology partnerships outperform low-technology partnerships in both profits and superior commercialization hit rate, high-technology interfirm partnerships are not superior in terms of product commercialization, where both high- and low-technology partnerships have comparable results. Content analysis of critical incidents reveal that when interfirm NPD partnerships make strategic efforts to change their NPD activities (e.g., permanent and long-term changes, such as global standardization of collaboration platforms), such efforts significantly impact key performance measures, such as product costs and revenues. Furthermore, strategic efforts to change NPD activities are associated with process-level performance outcome measures, such as lowered stress on members involved in the NPD effort. Both findings are rather interesting and deserve future investigation.

Because large-scale strategic efforts appear to be ongoing in interfirm NPD partnerships, future research on technology and knowledge transfer between partners is thereby warranted (Swink, 2000; Swink & Mabert, 2000). In a way, it is quite artificial to distinguish between suppliers and buyers in NPD partnerships, because technology and know-how flows both ways in collaborative interfirm NPD partnerships. We still know little about how technology and knowledge are shared in interfirm NPD partnerships, especially when strained by high technology. More work is thus prescribed.

Implications for Decision Makers

In this study, suppliers were found to be under the greatest stress to overcome the limitations apparently rendered by the high-technology context of NPD partnerships, so those concerns were addressed first. We believe many suppliers in NPD partnerships are uniquely positioned to benefit from their new-found position of technological strength in the auto industry, and that this effect could be observed in other industries with similar challenges. The auto industry is undergoing a shift in locus of innovation, that is, the locus is moving upstream to suppliers, thereby serving as an example for other industries. These implications are divided into three different sets of decision makers: product technology suppliers, their customers (in auto, i.e., the OEMs), and IT suppliers.

Product technology suppliers

Although suppliers in the auto industry have successfully used IT to overcome many of these new challenges of technology leadership, many other suppliers are still clearly struggling. Alignment with other suppliers of note is apparently
warranted, and evidence of that can be seen in the business press as some of Ford’s suppliers have refused to sign recent purchase contract agreements unless their trade secrets are protected. Suppliers complain that buyers (OEMs) want new technology for nothing and then give it away to other (competing) suppliers when bids are let. But with market shares of all OEMs equalizing, it appears that there is a strategic opportunity to collaboratively create product value and be more careful when replacing existing suppliers for new suppliers. Leverage of a technology position goes without saying, but it is clear that if some suppliers put as much effort into developing creative ways of working together with buyers (OEMs) (as they have already done in the lab and engineering testing arenas), things might actually improve. NPD executives alone cannot be held accountable when product and IT technology enters the context of interfirm NPD partnerships. Middle managers, technologists, purchasing agents, and marketing managers will also have to step up and shoulder this mantle. The more new technology in the product, the greater the effect. So technology suppliers will have to combine any new methods they have adopted for protecting intellectual property (e.g., better collaborative and other IT support) with the old methods (e.g., faster patent protection), and perhaps even revisit currently suspect methods (e.g., increased secrecy) for new inspiration.

Low-technology suppliers are also under new pressures to be creative under these evolving conditions. If high-technology suppliers are challenged and overcome their barriers to success with IT, then what of the lower-technology suppliers, customers, and subsystems in the value chain? Even if resources for technological change are limited in low-technology sectors, this does not relieve managers of their responsibility for creative enactment of their business futures. As information technologies stabilize, and become more standardized, low-technology suppliers can also participate in this new model of the value-added chain.

**Buyers (OEMs)**

Buyers (OEMs), often on the receiving end of technology, in some way probably will have to undergo complementary changes. On the one hand, if buyers of technology refuse to protect intellectual property rights of suppliers, suppliers may choose to go elsewhere or, at a minimum, diversify. The global markets and changing technology scene, especially in some areas like sustainable design, are here to stay and are quite challenging (The Economist, 2004). In addition to working with suppliers, OEMs in the auto industry, at least, have precedents to emulate in cooperating with their competitors as well. Ford’s recent adoption of Toyota hybrid drive-train technology is one of the most innovative technology that leaps to mind, but there have been others, especially in the area of sustainable design (cf. Ettlie, 2000).

A new view of the make-buy decision emerges to frame decision making in this study. This is no longer the already challenging issue of what product technology to make and what product technology to buy. It now becomes an issue of what IT will be needed to meet new collaborative challenges ahead, and how to approach these decisions. The current research, and research that is likely to appear on the horizon addressing this issue, will likely begin to flesh out more details of this challenging future, but it seems clear that the technologies of collaboration have, and will continue to become, central to the evolving restructuring of many
global industries like automobiles. The challenge for decision makers is to be able to have an enlightened view of a much greater range of options that will likely appear in both product process (e.g., manufacturing) and IT. For example, it is not clear how modular manufacturing is likely to be affected by these trends. Modular manufacturing is a complex way of doing business, and often presents new challenges to value capture and cost reduction. And, if there continues to be competitive stress, consolidation, repositioning, new partnerships, and emerging new product technologies, then the effects found in this study are likely to become stronger as moderators of these conditions.

Information technology suppliers

For information technologists, both in the supply chain and within product technology originating firms, the challenges will never be over. It is clear that in the auto industry, as in many other sectors outside manufacturing like health care, there will continue to be significant investments in IT. Those investments aimed at improving the efficiency and effectiveness of developing new offerings (new products and services) are likely to take on increased importance. Unless both internal IT units and IT suppliers are prepared for this future, the challenges to survive and thrive will become even more daunting. Smaller firms that are in this mix will have even greater risks, and the premium placed on the correct choices for alliances will be critical. [Received: December 2004. Accepted: April 2006.]

REFERENCES


APPENDIX A: MEASUREMENT ITEMS FOR PRINCIPAL CONSTRUCTS

1. NPD Partnership Dynamic Capabilities
   a. Absorptive Capacity
      We are able to identify, value, and import external knowledge from our external partner.
      We have adequate internal routines to analyze the knowledge obtained from our external partner.
      We can successfully integrate existing knowledge with new knowledge acquired from our external partner.
      We can successfully exploit the new integrated knowledge into concrete applications.
   b. Coordination Capability
      We ensure that the output of our work (knowledge, expertise, resources) is of a form useful to our partner.
      We ensure that the output of our work is available to our external partner when needed (at the right time).
      We ensure that the output of our work is synchronized with the work of our external partner.
      We ensure that the output of our work is available to our partner where it is needed (at the right place).
      We ensure an appropriate allocation of resources (e.g., information, time, reports) with our external partner.
   c. Collective Mind
      Members from both firms make their contributions to the joint outcome with attention and care.
      Members from both firms have a global perspective of each others' tasks and responsibilities.
      Members from both firms carefully interrelate actions to each other to maximize joint performance.

2. NPD Partnership Success
   New Product Success Rate: Based on your organization's definition of a successful new product (e.g., some multiple of return on investment), about what % of all new products introduced into the market during the last 5 years were successful?
   Superior Product Commercialization: Rate your performance relative to your major competitors (e.g., internal rate of return).

3. High-Technology versus Low-Technology Context (R&D Ratio)
   R&D spending the previous year as a proportion of sales

4. IT Support for NPD
   a. IT Capabilities
      IT is very capable of performing its NPD support job.
      IT is known to be successful at the things it tries to do in NPD support.
      IT has much knowledge about the work that needs to be done to support NPD.
      I feel confident about IT's skills to support NPD.
      IT has specialized capabilities that can increase our performance.
      IT is well qualified.
   b. IT–Engineering Relationship
      IT is very concerned about my welfare and the welfare of engineering.
      My needs and the desires of my group are very important to IT.
      IT would not knowingly do anything to hurt me or engineering.
APPENDIX A: continued

IT really looks out for what is important to me and engineering.
IT will go out of its way to help me and my group.

c. IT Principles
IT has a strong sense of justice (i.e., impartial adjustment of conflicting claims).
I never have to wonder whether IT will stick to its word.
IT’s actions and behaviors are not very consistent.
I like IT’s values.
Sound principles seem to guide top management’s behavior regarding IT.

APPENDIX B: CONVERGENT AND DISCRIMINANT VALIDITY OF PRINCIPAL CONSTRUCTS (PLS CONFIRMATORY ANALYSIS PROCEDURE)

<table>
<thead>
<tr>
<th></th>
<th>IT Support for NPD</th>
<th>Dynamic Capabilities</th>
<th>Success Rate</th>
<th>Product Commercialization</th>
<th>R&amp;D Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT Support for NPD1</td>
<td>.743</td>
<td>.313</td>
<td>.072</td>
<td>.101</td>
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<td>IT Support for NPD2</td>
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<td>.132</td>
<td>.111</td>
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<td>.103</td>
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<td>.125</td>
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<td>IT Support for NPD4</td>
<td>.756</td>
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<td>.116</td>
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<tr>
<td>IT Support for NPD5</td>
<td>.746</td>
<td>.247</td>
<td>.005</td>
<td>.066</td>
<td>.071</td>
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<tr>
<td>IT Support for NPD6</td>
<td>.798</td>
<td>.267</td>
<td>-.019</td>
<td>.141</td>
<td>.138</td>
</tr>
<tr>
<td>IT Support for NPD7</td>
<td>.882</td>
<td>.240</td>
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Variance Explained = 81.1%

|                | 20.7 | 17.1 | 15.7 | 14.7 | 12.9 |

Numbers in boldface type represent own-construct cross-item correlations.
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