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Exploratory and Exploitative Knowledge Sharing in Interorganizational Relationships

Ghiyoung Im

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Exploratory and Exploitative Knowledge Sharing in Interorganizational Relationships

By
Ghiyoung Im

A Dissertation Submitted to the Department of Computer Information Systems in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

August, 2006

ACCEPTANCE

This dissertation was prepared under the direction of Ghiyoung Im's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Robinson College of Business of Georgia State University.

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ABSTRACT

A growing body of research investigates the role that organizational learning plays in generating superior firm performance. Researchers, however, have given limited attention to this learning effect in the context of long-term interorganizational relationships. This paper focuses on a specific aspect of learning, that is, explorative and exploitative knowledge sharing, and examines its impacts on sustained performance. We examine interorganizational design mechanisms and digitally-enabled knowledge representation as antecedents of knowledge sharing. The empirical context is dyadic relationship between a supply chain solutions vendor and its customers for two major classes of supply chain services. Our theoretical predictions are tested by using data collected from both sides of this customer-vendor dyad. The findings suggest that dual emphasis on exploration and exploitation is important for sustained relationship performance for customers. The customer evaluates balancing exploration and exploitation important whereas the vendor emphasizes only on exploitation.

Keywords: Interorganizational relationships, knowledge sharing, exploration, exploitation, learning paradox, contextual ambidexterity, knowledge representation, boundary objects

EXTENDED ABSTRACT

A growing body of research investigates the role that organizational learning plays in generating superior firm performance. Researchers, however, have given limited attention to this learning effect in the context of long-term interorganizational relationships. This paper focuses on a specific aspect of learning, that is, explorative and exploitative knowledge sharing, and examines its impacts on sustained performance. We examine interorganizational management systems (i.e., contextual ambidexterity) and digitally-enabled knowledge representation as antecedents of knowledge sharing. Knowledge sharing is defined as the acquisition and exchange of internally and externally generated knowledge that is pertinent to the interorganizational relationship.

Theoretical Background. Organizational performance is considered a joint function of exploration and exploitation. Having both occur simultaneously is considered a primary factor in organizational survival and prosperity. Exploration without exploitation may lead to investigating many innovative projects without reaping any benefits. Exploitation without exploration is likely to lead to dwindling opportunities to sustain competitive advantage. We suggest the positive effects of exploratory and exploitative knowledge sharing on relationship performance. In addition, a dual emphasis on exploratory and exploitative knowledge sharing is expected to generate synergies toward relationship performance.

As the antecedents of knowledge sharing, we suggested contextual ambidexterity and knowledge representation connectivity and conjectured that they have positive effects on exploratory and exploitative knowledge sharing, respectively. Contextual ambidexterity

is defined as the behavioral capacity of an interorganizational relationship to allow for the simultaneous achievement of alignment and adaptability. Alignment refers to coherence among all patterns of activity in the relationship that are geared toward achieving the same goals. In contrast, adaptability refers to the capacity to quickly reconfigure activities in the relationship in order to meet changing requirements of the business environment.

Knowledge representation connectivity refers to the extent to which boundary objects are used to inter-connect knowledge stocks of actors across their boundaries. We specifically focus on digital boundary objects. Boundary objects are a key element of knowledge representation that provides an effective shared context to facilitate knowledge sharing within or across firm boundaries.

We also hypothesize moderating effects of knowledge representation connectivity on the relationship between contextual ambidexterity and knowledge sharing, and of environmental uncertainty on the relationship between knowledge sharing and performance.

Method. The empirical context for this research is dyadic relationships between customer and vendor. The specific unit of analysis for the research is the relationship between an individual customer and a specific vendor for a particular business unit. Our theoretical predictions pertaining to the behaviors of exploration and exploitation were tested on both sides of the customer-supplier dyads for one of two supply chain services: freight services and logistics services. The final usable sample from customers consisted of 238 surveys while that from the vendor's account managers is composed of 76 surveys.

Results. On the customer side, both explorative and exploitative knowledge sharing have a significant effect on performance, but exploitative knowledge sharing has a relatively weak effect. The effect of exploitative knowledge sharing on performance becomes insignificant when a direct path is added from contextual ambidexterity to performance. There also exists synergy with the duality between exploratory and exploitative knowledge sharing that enhances performance and reduces variance of performance gains. Management systems are effective in establishing capacity for alignment and adaptation and enable the duality.

On the vendor side, strong effects on the impact of exploitative knowledge sharing on performance are found, whereas no evidence was found on the impact of explorative knowledge sharing. Exploitative knowledge sharing fully mediates the impact of contextual ambidexterity on performance. Management systems also support both types of knowledge sharing. Knowledge representation connectivity affects both types of knowledge sharing on the customer side, whereas this effect is observed only on exploitative knowledge sharing on the vendor side. Moderation effects associated with knowledge representation connectivity and environmental uncertainty are not observed across the customer and vendor dataset.

Discussions. Tested with customer data, the results suggest that a dual emphasis on explorative and exploitative knowledge sharing enhances relationship performance and reduces its variance. This reduced variance-to-mean performance ratio suggests that the two types of knowledge sharing can be reinforcing and synergistic in long-term interorganizational relationships.

We find that contextual ambidexterity fosters both types of knowledge sharing, which, in turn, yield sustained performance benefits. It appears that contextual ambidexterity supports the two distinctive processes (i.e., differentiating and integrating) in facilitating individuals in a relationship to share both types of knowledge simultaneously. Differentiating processes help individuals clarify distinctions between exploration and exploitation while integrating processes reconcile conflicts posed by opposing forces and allows for the pursuit of both activities.

Knowledge representation connectivity promotes exploratory and exploitative knowledge sharing for customers, whereas it facilitates only exploitative knowledge sharing for the vendor. For the vendor, knowledge representation connectivity is not effective in promoting exploratory knowledge sharing with its customers. Large vendors run standardized systems to fulfill diverse needs from customers. It appears that this standardization lends itself to prevent the exchange of exploratory knowledge by vendors. Different perceptions regarding what is considered exploration and exploitation between the partners may be another possible reason for the observed insignificant relationship between knowledge representation connectivity and exploratory knowledge sharing.

While customers realize performance gains from explorative and exploitative knowledge sharing, the vendor realizes performance gains from exploitative knowledge sharing. This suggests that vendors, especially large ones with significant centrality and power in their industry, maybe focused on scale economies and revenues.

Conclusion. While the basic tenets of our arguments were supported, the results painted a more complicated picture as to which types of innovation are important for the parties involved. Specifically, the customers emphasized exploration and exploitation

simultaneously whereas the vendor was focused on exploitation. This implies that relationships do not operate uniformly as to what innovations are important for value creation when each firm in the relationship has different goals for the relationship. These different emphases are correspondingly reflected on their use of information technology for innovation. These results imply that relationship managers must be vigilant about the possible differing goals for innovation across the border and look for ways to overcome this discrepancy to achieve heightened mutual performance.

Keywords: Interorganizational relationships, knowledge sharing, exploration, exploitation, learning paradox, contextual ambidexterity, knowledge representation, boundary objects

1. INTRODUCTION

Productivity is still very important, but if you look back at GE's businesses over the past decade or so, those that have been managed for both productivity and growth have done best.

-- J. R. Immelt, Chairman and CEO, General Electric
Harvard Business Review, June 2006 (p. 62)

Exploration and exploitation are two different types of organizational learning. Exploration regards the pursuit of new knowledge, and exploitation refers to the use and refinement of existing knowledge. Organizational performance is considered a joint function of exploration and exploitation (Gavetti et al. 2000; March 1991). Having exploration and exploitation occur simultaneously is considered a primary factor in organizational survival and prosperity. Exploration without exploitation may lead to investigating too many innovative projects without reaping any benefits. Exploitation without exploration is likely to lead to dwindling opportunities to sustain competitive advantage.

Historically, having exploration and exploitation activities simultaneously is considered challenging (Levinthal et al. 1993; March 1991). A primary reason for this challenge is that exploration or exploitation activities tend to drive out the other. The returns to exploitation are certain and reliable, whereas the returns to exploration are uncertain and changing. Thus, organizations tend to favor the short-term virtue of exploitation and discount the value of exploration, a phenomenon known as a competency trap. Similarly, exploration can drive out exploitation. As organizations engage in experimentation, they inevitably generate failures. A series of these failures can

lead to subsequent experimentation and new searches that do not accrue any rewards, a phenomenon known as an innovation trap.

This duality between exploration and exploitation has been a consistent theme among researchers, and applied to a variety of problems, such as the productivity dilemma (Abernathy 1978), core capabilities and core rigidities (Leonard-Barton 1992), static and dynamic efficiency (Ghemawat et al. 1993), strategic renewal (Crossan et al. 1999), the ambidextrous organization (Benner et al. 2003; O'Reilly et al. 2004; Tushman et al. 1996), and search and stability (Rivkin et al. 2003; Siggelkow et al. 2003). Despite this consistent recognition of the phenomenon, there still remains a significant need for additional conceptualization and empirical investigations of these learning activities within and especially across firms. For example, few researchers (e.g., Kyriakopoulos & Moorman (2004a); Mizik & Jacobson (2003)) have investigated this duality with regard to performance implications.

This research examines the duality of exploratory and exploitative knowledge sharing in dyadic interorganizational relationships. Exploratory and exploitative knowledge sharing are recognized as dynamic capabilities that influence relationship performance. Knowledge sharing capability is defined as an interorganizational capability to acquire and exchange internally and externally generated knowledge that is pertinent to the interorganizational relationship. We investigate how exploratory and exploitative knowledge sharing is shaped by the organizational design mechanism of the relationship, and how organizational design mechanisms are complemented by knowledge representation capability. We also investigate the implications of the environmental

context of the relationship on performance gains that are realized by differential emphasis on exploratory and exploitative knowledge sharing.

The four specific research questions addressed are:

(a) How do exploratory and exploitative knowledge sharing impact relationship performance in dyadic interorganizational relationships?

(b) What is the role of knowledge representation capability in facilitating exploratory and exploitative knowledge sharing in dyadic interorganizational relationships?

(c) What organizational design mechanism enables simultaneous exploratory and exploitative knowledge sharing?

(d) What are the roles of environmental context in determining the impacts of exploratory and exploitative knowledge sharing on relationship performance?

The empirical context for this research is the relationship between customers and a vendor (SupplyChainCo) in the logistics industry in the United States. The unit of analysis is the dyadic relationship between a customer and a vendor for a particular business unit. Our theoretical predictions that pertain to the duality of exploratory and exploitative knowledge sharing were tested on both sides of the customer-supplier dyads for one of the two supply chain services (i.e., freight services and logistics services). The final usable sample from customers is comprised of 238 surveys while that for the vendor is collected from account managers and consists of 76 surveys.

On the customer side, both explorative and exploitative knowledge sharing have a significant effect on performance, while on the vendor side, a strong effect is found only

on the impact of exploitative knowledge sharing on performance. Tested with the customer data, synergy is found in the duality between exploratory and exploitative knowledge sharing that enhances performance and reduces variance in performance gains. Organizational design mechanisms (i.e., contextual ambidexterity) are effective in establishing the capacity for alignment and adaptation and enable the duality. Knowledge representation capability (i.e., knowledge representation connectivity) affects both types of knowledge sharing on the customer side, whereas this effect is observed only on exploitative knowledge sharing on the vendor side. Moderation effects associated with knowledge representation connectivity and environmental uncertainty are not observed across the customer and vendor data.

The remainder of the research is organized as follows. First, we briefly review the relevant literature, specifically focusing on exploratory and exploitative learning. Second, we introduce our research model and hypotheses. Third, we map out the research method. We conclude the paper with a discussion of our results, including theoretical and practical implications, and future research.

2. THEORETICAL BACKGROUND

In this section, we first introduce exploratory and exploitative learning. We then describe interorganizational knowledge sharing with regard to exploration and exploitation. Finally, the concepts of knowledge representation and boundary objects are introduced and the importance of knowledge representation capabilities as facilitators of knowledge sharing is discussed.

The theoretical basis of this research on knowledge sharing in interogranizational relationships is rooted in the exploration and exploitation framework (Levinthal et al. 1993; March 1991), as applied to organizations (Benner et al. 2003; O'Reilly et al. 2004; Tushman et al. 1996), to organizational learning (Gavetti et al. 2000), to marketing (Berthon et al. 1999; Mizik et al. 2003), to strategic management (Rothaermel et al. 2004), and to interorganizational relationships (Gulati et al. 1998; Koza et al. 1998).

2.1 Exploration and Exploitation

2.1.1 Strategic Orientation for Exploration and Exploitation

Organizational researchers primarily have addressed the importance of exploration and exploitation occuring simultaneously within a firm. Decades ago, Abernathy (1978) emphasized that a firm's stress on productivity gains dampened its innovativeness and flexibility. He suggested that the competitive advantage of a firm lies in not only having the ability to increase efficiency but also in having the simultaneous ability to innovate. O'Reilly and Tushman (2004) also recognize that maintaining a variety of innovation

efforts is essential for long run competitive advantage. They highlight that firms have to pursue incremental, architectural, and discontinuous innovations at the same time.

Exploratory and exploitive organizational learning are complementary as well as conflicting. Figure 1 shows four different modes of strategic orientation within and across firms. When both exploration and exploitation orientation are low, there is little interaction between the two orientations. Firms are largely isolated from their environment and are less concerned with improving the status quo. Thus, there cannot be active learning, or subsequent synergy or conflicts. Firms in this mode are obsessed with their internal problems and operate at the expense of both exploration and exploitation (Berthon et al. 1999).

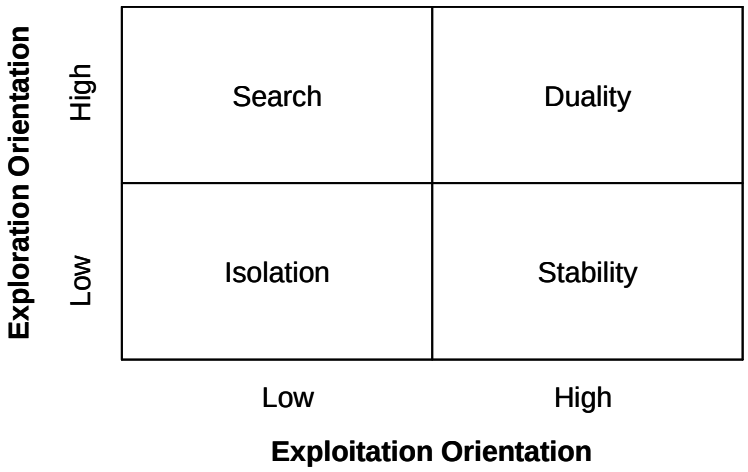

Figure 1. Strategic Orientation Modes (Adapted from Berthon, Hulbert, & Pitt (1999))

Firms that are high in exploitation but low in exploration emphasize stability over search. The returns of exploitation are certain, obtainable in short periods of time, and realizable within visible boundaries of markets, whereas those of exploration are

uncertain, available only after quite a while, and pervasive in effects (March 1991). Thus firms in this mode tend to make more efforts to reap fruit from areas in which they have competencies. This tendency toward stability devolves into a focus on a few areas, and disrupts momentum and efforts to search for opportunity. For firms focused on exploitation, there is a danger that exploitation can drive out exploration.

Similarly, the emphasis on search can clash with the movement toward stability. The emphasis on search is difficult to sustain. Disruptive innovation that is focused on search tends to overturn existing competencies, skills, and know-how (Gatignon et al. 2002). The market for new products via disruptive innovation is unstable in nature and does not have detailed analyses on which to base decisions (Christensen 1997). Even if the new market exists on a small scale, it cannot satisfy the growth needs of large firms. Also, the supply of technology may not equal market demand. In this situation, applying traditional management practices that lead to success with sustaining technologies leads to failure if using disruptive technologies (Christensen 1997). As a result, management may abandon the current disruptive product and pursue another search. In the end, there is a tendency for exploration to drive out exploitation.

Exploration and exploitation can be complementary and synergistic only when firms maintain a duality between the two. When having the two, we are concerned with the need to consider both forms of learning and to identify a proper level of duality in given situations. Firms that have both elements suffer from neither a lack of returns in their investment nor obsolescence in knowledge (Levinthal et al. 1993). Sufficient exploitation ensures their current viability and exploration ensures their future viability. Further, dual firms should be able to overcome the forces that drive exploration to be dominant over

exploitation or vice versa. These firms should be able to synergistically integrate the results from both types of learning by maintaining an appropriate duality suitable for each business context.

A recognition of the importance of exploration and exploitation can be found in the recent debate among marketing researchers about guiding templates for organizational business activities (Berthon et al. 1999). An innovation orientation school argues that customers will prefer those products and services with technological superiority. This school is generally concerned with new products, innovation, and discontinuous improvement. On the other hand, the customer orientation (or market orientation) school leans toward identifying the requirements of the target market and satisfying these needs for competitive advantage. It deals with matters such as customer service, customer satisfaction, and customer focus. Moreover, there has been an ongoing debate to determine the best strategy for organizations. Researchers argue that one is a subset of the other, or one is necessarily or exclusively an antecedent of the other. However, Berthon, Hulbert, and Pitt (1999) assert that market orientation and innovation orientation are two distinct constructs that can interact complementarily or conflict. They also suggest that, for long term competitive advantage, the firm must have organizational ambidexterity by meeting the needs and wants of current customers, while also innovating to meet their future needs and wants.

2.1.2 Exploration and Exploitation in Interorganizational Relationships

A growing body of literature has recognized the importance of learning in interorganizational relationships. Researchers consider interorganizational collaboration a

viable method of learning (Hamel 1991; Larsson et al. 1998; Powell 1998; Powell et al. 1996). Relational learning plays a critical role in forming and sustaining strategic alliances (Koza et al. 1998; Sobrero et al. 2001). Relational learning between firms is facilitated when the firms in the strategic relationship transfer skills, organizational routines, and knowledge that comprise the resources. The literature suggests that firms in a strategic alliance can have a wide range of structural flexibility in solving transaction cost problems from transacting parties (Chi 1994). Although it depends on the effectiveness of remedying mechanisms (for example, apportionment of residual claimancy and assignment of residual control in transaction cost problems between firms), there are virtually no obstacles to learning via external activities (Chi 1994). First, a quest for relational learning or knowledge acquisition is recognized as a salient motive for many alliances (Berg et al. 1981). Firms enter into exploration alliances to seek new opportunities (Koza et al. 1998) and to take advantage of external resources that can expand the internal asset base (Clark 1989; Dyer 1997; Sobrero et al. 2001; Wind et al. 1997). Firms also engage in exploitation alliances to increase the overall efficiency of the process (Sobrero et al. 2001) and to take advantage of an existing capability (Koza et al. 1998). In exploitation alliances, firms can leverage complementary assets and the partner's resource endowments. Wuyts, Dutta, and Stremersch (2004) report that interfirm R&D alliances can enhance both a firm's radical and incremental innovation. Both of these innovations reflect exploratory and exploitative learning by firms as a result of interorganizational relationships. The choice between a predominantly exploration or and exploitation alliance is determined by several factors such as anticipated business benefits, perceived environmental turbulence of managers, strategic intent, and past

business experience. Relational learning also helps firms develop the knowledge-based trust (Shapiro et al. 1992) that sustains alliances. Through ongoing interactions for learning, firms develop mutual understanding and trust. This knowledge-based trust creates self-enforcing mechanisms in an exchange relationship, and can substitute for contractual safeguards (Bradach et al. 1989; Powell 1990).

2.1.3 Information Technology for Exploration and Exploitation

Information technologies play a key role in fostering two different types of (inter)organizational learning activities. First, information technologies become a direct platform for exploration and exploitation. Some researchers have connected *specific* features of information technologies to organizational or individual learning (Chou 2003; Goodman et al. 1998; Markus et al. 2002; Stein et al. 1995). An example of IT features investigated for learning includes communication, storage and indexing, and search and matching (Chou 2003; Goodman et al. 1998). Specifically, Markus, Majchrzak, and Gasser (2002) show that information technologies can be designed and deployed to support an emergent knowledge process of deliberation, i.e., exploration found in basic research, new product development, and strategic business planning, via more organic approaches than rigid structures. Some of the design and development principles for supporting emerging knowledge processes (EKP) include (1) design for knowledge translation through radical iteration with functional prototypes, (2) design for implicit guidance through a dialectical development process, and (3) componentize everything, including the knowledge-base. Vandenbosch and her colleagues (1996; 1997) show that executive information systems can be used for information retrieval such as scanning and search. Focused search capabilities provide executives with answers to specific questions

or well-defined problems, whereas scanning capabilities can be used to help formulate problems and promote creativity.

Others have emphasized the *overall* capabilities of information technologies on organizational or individual learning (Alavi 1994; Irani et al. 2001; Kock et al. 1998; Kwok et al. 1998; Lee et al. 2003; Scott 2000; Subramani 2004; Vandenbosch et al. 1997). Scott (2000) recognizes that IT facilitates both lower-level and higher-level relational learning. Lower-level relational learning occurs when an organization adjusts its behavior via the monitoring features of IT. Higher-level relational learning arises as organizational assumptions are challenged and an organization establishes new routines because of IT-enabled collaboration and IT-based modeling technologies. Subramani (2004) illustrates that supply chain management systems can be appropriated for exploitation, e.g., transaction processing activities by suppliers, and exploration, e.g., support for non-routine, unstructured tasks.

Second, information technologies can be leveraged as a platform to create organizational capabilities that facilitate exploration and exploitation activities. Sambamurthy, Bharadwaj, and Grover (2003) recognize that information technologies can support organizational capabilities, such as digital options and agility. Digital options refer to a set of IT-enabled capabilities in the form of digitized organizational work processes and knowledge systems. Digital options lead to agility, which is the ability to detect and seize market opportunities with speed and surprise. Three types of agilities (i.e., customer, partnering, and operational) have elements of exploratory and/or exploitative activities. In sum, information technologies can be used to create digital options that enable exploratory and/or exploitative activities.

2.2 Knowledge Sharing

2.2.1 Knowledge Sharing at Various Levels

Knowledge is far from being easily transferable and is subject to knowledge sharing barriers. Researchers call it immobility (Attewell 1992), inertness (Kogut et al. 1992), internal stickiness (Szulanski 1996), and sticky information (von Hippel 1994). However the creation and sharing of knowledge are considered to be a basis for competitive advantage in firms (Argote et al. 2000). The kinds of knowledge that have been investigated include knowledge that concerns production technology (Dyer et al. 2000; Gupta et al. 2000; Kotabe et al. 2003; Simonin 1999; Zander et al. 1995), business processes or practices (Darr et al. 1995; Szulanski 1996), sales and marketing (Gupta et al. 2000; Hamel 1991; Schulz 2001), and management (Gupta et al. 2000).

One way to view knowledge is to determine whether it is focused on procedural aspects or declarative aspects. Procedural knowledge is concerned with "how to do things" (Alavi et al. 2001) and involves know-how embedded in skills or routines. The nature of this know-how can be domain-specific and is important for some specific situations. Declarative knowledge is knowledge about "facts or events," that is, know-about (Alavi et al. 2001).

Knowledge sharing is defined as the exchange of skills, know-how, and information across the firms involved. Strategic alliances among firms form an interorganizational network of differentiated units. Knowledge sharing in the network can be studied on at least three levels: nodal (i.e., the behavior of individual units), dyadic (i.e., the joint behavior of unit pairs), and systematic (i.e., the behavior of the entire network) (Gupta et

al. 2000). Given the availability of prior works and the complexity of the research phenomenon, we have selected the dyadic level of analysis for knowledge sharing. Specifically, we are interested in knowledge outflows from customers or suppliers to their partners. That is, knowledge sharing is investigated from the knowledge sender's perspective. Some researchers investigate the phenomenon from the sender's perspective (Moorman 1995) whereas others examine it from the sender's as well as the receiver's viewpoint (Gupta et al. 2000; Schulz 2001; Straub et al. 2004a).

We take all means for sharing knowledge and information between firms, including meeting, product reviews, telephone, e-mails, electronic transactions, and prototypes into account. This inclusion allows us to capture the overall characteristics of knowledge and information being shared between the firms. Knowledge sharing can be purposive (formal) or relational (informal) (Rulke et al. 1998). Purposive sharing involves deliberate attempts to transfer knowledge. The mechanisms include training members of the partner firm, communicating between members of both firms, or providing documents, blueprints, and descriptions of the organizational structure to the partner firm (Argote 1999). Relational sharing occurs during personal contacts that involve casual conversations concerning new or incremental product development. We take both purposive and relational means of knowledge sharing to capture the phenomenon into account.

The literature covers various processes for knowledge sharing. Some researchers define knowledge sharing as multi-stage processes such as initiation, implementation, ramp-up, integration (Szulanski 1996), search and transfer (Hansen 1999), or sharing and

assimilation (Simonin 1999). In this research we confine knowledge sharing to the *exchange process* among other sharing processes.

Supply chain management researchers have investigated information sharing and its performance implications, which are partly related to knowledge sharing (Cachon et al. 2000; Cachon et al. 2001; Lee et al. 1997; Lee et al. 2000b). Their research has focused on mathematical modeling and mainly on the operational aspects of information sharing (e.g., Li (2002); Raghunathan (2001); Sahin and Robinson (2002)). Methodologically, simulation has been used frequently to validate the model, yet systematic empirical research from a strategy viewpoint is generally scant (see Cachon and Fisher (2000)).

At the organizational level, the literature has dealt with knowledge or information sharing with regard to organizational learning (Sinkula 1994; Slater et al. 1995), information processes (Moorman 1995), and internal collaboration processes (Fisher et al. 1997). Information sharing, or information processes generally, which encompass information acquisition, information sharing, and information utilization, are known to be positively associated with customer satisfaction and new product success (Moorman 1995; Slater et al. 1995), and with internal relationship effectiveness (Fisher et al. 1997).

At the interorganizational level, researchers have addressed knowledge or information sharing with regard to social capital (Koka et al. 2002), channel communication (Mohr et al. 1990; Mohr et al. 1996), relationship learning (Selnes et al. 2003; Uzzi et al. 2003), marketing channels (Anderson et al. 1992; Cannon et al. 1999), and game theoretic perspectives (Straub et al. 2004b).

Interorganizational knowledge or information sharing is positively related to relationship effectiveness and efficiency (Koka et al. 2002; Selnes et al. 2003; Straub et

al. 2004b) and to relationship quality such as relationship satisfaction and commitment, and mutual coordination (Mohr et al. 1990; Mohr et al. 1996). Specifically, Uzzi and Lancaster (2003) find that different types of ties promote different types of knowledge sharing and different types of learning. They found that firms with arm's-length ties share public knowledge whereas those linked via embedded ties share private knowledge. Firms sharing public knowledge are engaged in exploitative learning and those sharing private knowledge are involved in exploratory learning. Exploratory learning is more complex than exploitative learning. Exploratory learning can be better facilitated by private knowledge that can support the testing of novel ideas and complex experimentation than by public knowledge.

The extant literature has suggested diverse dimensions of knowledge sharing within and across firms. The literature is found in a variety of areas such as strategy management (Koka et al. 2002), organization theory (Zahra et al. 2002; Zahra et al. 2000), market information activities (Maltz et al. 1996; Mohr et al. 1996), and information technology (Massetti et al. 1996; Straub et al. 2004b).

Researchers have identified the following three dimensions of knowledge sharing: knowledge volume, knowledge diversity, and knowledge richness. Knowledge volume refers to the quantity of knowledge that a firm can access via relationships. Knowledge diversity pertains to the variety of knowledge that is available to a firm through its relationships. Knowledge richness focuses on the quality of knowledge, which becomes a basis to change understanding within a time frame (Daft et al. 1986). Drawing on information richness sub-dimensions in marketing, knowledge richness can be further divided into accuracy, relevance, clarity, and timeliness (Deshpande et al. 1982; Gupta et

al. 1988; Maltz et al. 1996). These sub-dimensions are also mentioned concerning end-user computing satisfaction in the information technology literature (Doll et al. 1988; Somers et al. 2003). In this research, knowledge sharing is considered holistically without characterizing each dimension separately.

2.2.2 Knowledge Sharing Capability

The simultaneous occurrence of exploratory and exploitative knowledge sharing is a dynamic capability embedded in interorganizational routines and processes that can influence relationship performance (Benner et al. 2003; Uzzi et al. 2003). *Knowledge sharing capability* is defined as an interorganizational capability to acquire and exchange internally and externally generated knowledge across the firms in the relationship. The goal is to take advantage of current technologies and resources existing in the interorganizational relationship to secure efficiency benefits via exploitative knowledge sharing while creating variation and new opportunities through exploratory knowledge sharing. This capability, in the form of processes and routines, provides the relationship with the ability to create and appropriate knowledge for exploration and exploitation in order to deal with market dynamism. The capability becomes a foundation for the relationship to achieve higher competitive advantage that leads to a higher performance than would be possible with either exploratory or exploitative knowledge sharing capability alone. Effective interorganizational relationships may share commonalities with regard to this capability among multiple relationships (Eisenhardt et al. 2000). However, knowledge sharing capability brings different values to each relationship in which it is present because it varies in the specific ways it develops and uses this capability in unique circumstances.

2.2.3 Interorganizational Knowledge Sharing

Knowledge sharing. We identify organizational exploratory and exploitative knowledge sharing as primary mechanisms of organizational learning. This view is consistent with the literature that suggests learning involves the processes through which knowledge is created, shared, evaluated, and combined (Argote 1999; Huber 1991; Selnes et al. 2003; Sinkula 1994; Slater et al. 1995; Vera et al. 2003). Firms learn, innovate, and renew themselves through knowledge that has been created within and across firms or knowledge that has been shared among firms with intimate relationships.

Organizational learning. Organizational learning refers to the study of the change learning processes in thought and action of and within firms (Argyris et al. 1978; Miller 1996; Tsang 1997). Thus, the learning process involves both cognitive and behavioral change. In this view of organizational learning, learning and knowledge are iterative and reinforcing as learning produces new knowledge, and at the same time knowledge affects learning (Vera et al. 2003). Firms learn, innovate, and renew themselves through the knowledge that has been created within the firm or that has been shared among the firms with which it has intimate relationships. At the same time, firms that have learned from past knowledge will institutionalize the knowledge creation and sharing processes, and exploit the current systems, strategies, and routines, thus fostering a generation of new knowledge.

Relational learning. Relational learning via interorganizational exploratory and exploitative knowledge sharing is a specific form of organizational learning. It shares commonalities with organizational learning, but has uniqueness as well. Our conceptualization of exploratory and exploitative knowledge sharing is an element of

"relationship learning" (Selnes et al. 2003), which is defined as a joint activity in which the two firms share knowledge, accomplish joint sense making, and develop relationship-specific memories to create more value together than they would create individually.

The uniqueness of relational learning compared with organizational learning is as follows. First, relationship learning requires a different governance structure as compared with organizational learning. The degree of integration and trust among the firms determines the motivation, processes, and effectiveness of relationship learning. Second, relationship learning involves idiosyncratic memory structures that cannot be found in organizational memory systems (Selnes et al. 2003). These memory structures reflect path dependence of relationships, common frames of reference, and common values of the two parties. The memory is created, managed, accessed, and used by both parties. Third, it results in different impacts in comparison with organizational learning. The outcome of relationship learning may strengthen or weaken the current governance structure. It may trigger additional levels of collaboration among the parties and may result in differential impacts for the parties involved.

2.2.4 Exploratory and Exploitative Knowledge Sharing

Drawing on the notion of three myopias of learning (i.e., temporal, spatial, and failure) (Levinthal et al. 1993), we propose the following definitions of knowledge sharing. *Exploratory knowledge sharing* is defined as the exchange of knowledge between firms in a long-term relationship seeking long-run rewards, focusing on the survival of the system as a whole, and pursuing risk-taking behaviors. *Exploitative knowledge sharing* is defined as the exchange of knowledge between firms associated with short run rewards by focusing on the survival of the components of the system and

pursuing risk-averse behaviors. These definitions are employed throughout this research, especially in developing the hypotheses.

These definitions are based on our detailed understanding of exploration and exploitation with respect to temporal, spatial, and failure myopia of learning. First, temporal myopia refers to the tendency to sacrifice the long-run to the short-run. Exploitation favors the short-run and thus may jeopardize long-run survival of a relationship. Exploitation emphasizes compliance and commitment to strategies and value creation approaches for short-term success (Ghemawat et al. 1993). To be successful in the long-run, we suggest that relationships require exploratory learning with originality in strategy and approaches to value creation.

Second, spatial myopia creates a tendency to ignore the larger picture and to focus on effects that are close to the learner. Since exploitation pursues a local search that is focused on a relationship's existing products, processes, and technological capabilities, it supports the survival of the system's components. In contrast, exploration seeks a distant search that provides new capabilities to a relationship in order to assist the survival of the system as a whole.

Finally, failure myopia is the tendency to overlook problem failure. The relationship tends to prefer safe bets with sure performance outcomes because the rewards of exploration may only be realized in the distant future. However, the long-run survival of a relationship is eventually determined by risk-taking exploratory activities that sometimes involve failure, uncertainties, and risks. Since lessons gained from success are favored, they may lead to a tendency to underestimate the risks of certain activities. Similarly, a series of failures may lead to a tendency to overestimate the risks of the

related activities. A risk-taking exploratory tendency should allow a relationship to have a more realistic view of the risks for exploratory activities, while allowing the risks to be overestimated.

Alternatively, exploration and exploitation can be described as two different search modes (March 1991). Exploration is characterized as a distance search for new capabilities while exploitation is concerned with a local search for improving and refining existing capabilities (Benner et al. 2002; March et al. 1958; Weick 1979). The criteria we use to characterize the two different searches are: (1) technological trajectory and (2) customer and market segments (Benner et al. 2003). First, exploration pursues new technological trajectories while exploitation builds on existing technological trajectories (Benner et al. 2003; Christensen 1997; Rosenkopf et al. 2001). The examples of technological innovation pursuing a distance search are radical innovation and architectural innovation (Benner et al. 2003). On the contrary, incremental innovation is an example of technological innovation used to conduct a local search. Architectural innovation involves changes in existing subsystems that are linked together. Radical innovations advance the price/performance frontier by fundamentally changing the technological trajectory (Gatignon et al. 2002). Such innovations require new concepts, skills, and knowledge that have not been used in prior innovations, and lead to developing new capabilities. Incremental innovations are accomplished by improving and refining existing concepts, skills, and knowledge following existing technological trajectory, and build on existing capabilities.

Second, innovations for new or emergent customer sets are often organizationally disruptive and require new knowledge or a departure from existing concepts and skills

(Benner et al. 2003). Such innovations require distance search and exploratory activities. On the other hand, innovations for current customer sets rely on existing concepts, skills, and knowledge. Thus, it requires local search and exploitative activities.

To have a superior capability for both exploratory and exploitative knowledge sharing, firms should establish well-organized routines and processes supported by information technology. Although the interest in environmental scanning has grown along with accelerated technological change (Kmetz 1998), the increasing role of information technology with respect to this scanning, or more broadly exploratory knowledge seeking, has received relatively scant attention (e.g., Subramani (2004); Vandenbosch and Huff (1997)). Further research about the exploratory role of information technology, both within and beyond firm boundaries, is needed, however.

2.3 Knowledge Representation and Boundary Objects

Knowledge sharing across firm boundaries requires facilitating mechanisms. Facilitating mechanisms provide the contexts in which different firms can solve the central tension between diversity and cooperation simultaneously, before they can share any kind of knowledge. Among diverse facilitating mechanisms, we focus on the notion of "boundary object" (Star et al. 1989) and reconceptualize it as "knowledge representation" that takes into account different levels of knowledge boundaries across firms (Carlile 2002; Carlile 2004a; Carlile et al. 2003). It is argued that knowledge representation provides a platform for knowledge sharing at the three levels of knowledge boundaries. We also suggest that most of the components for knowledge representation across firm boundaries are enabled by information technology.

2.3.1 Knowledge Representation

Knowledge representation refers to the codification of a firm's knowledge in the form of sharable objects across the parties involved. We use the term "representation," as it is used in requirements engineering (McDermid 1994), to mean the information product in a diagrammatic or formal notation that is gathered but needs to be organized and represented. However, our conceptualization of representation goes beyond diagrams and notations, to include non-notational, non-diagrammatic artifacts. Our conceptualization of knowledge representation is similar to knowledge codification (Schulz 2001; Zollo et al. 2002). However, we are not concerned with non-sharable objects across the parties involved.

Knowledge representation plays a central role in the knowledge sharing processes between the source and recipient of knowledge. When a particular knowledge is represented at the source, it is easily identifiable or searchable from the source of knowledge sharing (Carlile et al. 2003). Stored knowledge or a knowledge repository serves as an easily identifiable reference point because the source shares the whereabouts of the knowledge in which he or she is interested for transfer. Once the source has identified the knowledge, he or she makes an assessment of whether it is relevant to the task at hand (Carlile 2004a), or whether it is useful to be shared. Since the represented knowledge contains the terminology, protocols, and syntaxes that are shared and easily understandable, the source can make a quick decision about the value of the knowledge. When knowledge is not well-represented through common syntaxes, semantics, and protocols, it is expensive to access and assess. It is also difficult for sources and recipients to appreciate explicit knowledge if it is not well-represented or is tacit and

resides in experts. For example, tacit knowledge embedded in an expert provides transfer, accessibility, and understandability challenges to a novice (Hinds 1999) or to a specialist from another area (Dougherty 1992).

Researchers have identified several salient barriers for knowledge sharing, including lack of absorptive capacity by the recipient (Szulanski 1996), causal ambiguity (Szulanski 1996), an arduous relationship between the source and the recipient (Argote 1999), and knowledge ambiguity (Simonin 1999; Szulanski 1996). Among these, knowledge ambiguity has been recognized as one of the most important barriers to knowledge sharing (Crossan et al. 1999; Simonin 1999; Szulanski 1996).

Knowledge ambiguity refers to a lack of understanding of the logical linkages between inputs and outputs, and causes and effects that are related to technological or work processes (Simonin 1999). Kogut and Zander (1992; 1995) describe that the more codifiable and teachable the knowledge, the faster it is transferred to new workers. Simonin (1999) examines the role played by knowledge ambiguity in the process of knowledge sharing between strategic alliance partners. Among many antecedents of knowledge ambiguity, he identifies that the tacit nature of knowledge has a significant effect on ambiguity. The more tacit the knowledge, the greater the barrier to sharing leads and the desirability to codify the tacit knowledge in order to circumvent ambiguity (Simonin 1999). Knowledge representation helps gain perspective into the unique thought worlds of different types of communications in order to make the knowledge visible and accessible to others (Boland et al. 1995).

When knowledge is not properly represented to the parties involved, other mechanisms must be implemented to facilitate knowledge sharing. The alternative

methods could include tacit sharing mechanisms such as learning from experience and learning by doing in the presence of knowledgeable partners, face-to-face communication, and embedding a firm in an external relationship such as a community of practice or a consortia (Argote 1999; Simonin 1999).

2.3.2 Boundary Objects

Boundary objects are a key element of knowledge representation that provides an effective shared context to facilitate knowledge sharing within or across firm boundaries (Carlile et al. 2003). According to Star and Griesemer (1989), boundary objects are objects that are shared and sharable across different parties involved. In their study in Berkeley's Museum of Vertebrate Zoology, they questioned how one group of actors solves a central tension between divergent viewpoints (diversity) and the need for generalized findings (cooperation) in scientific work. They observed that standardization of methods and the development of boundary objects were central for translating between viewpoints. They distinguished four types of boundary objects: repositories, ideal types, coincident boundaries, and standardized forms. These objects are both adaptable to different viewpoints and robust enough to maintain identity across them. They may be abstract or concrete. These can be physical or digital objects, technologies, or techniques shared by the actors (Brown et al. 1998). They inhabit several intersecting social worlds and satisfy the information requirements of the actors involved (Star et al. 1989). Boundary objects are externalized knowledge that can be transferable within and across firms. Thus, knowledge representation in our conceptualization is *equivalent* to the specification of the knowledge across the firms in the form of boundary objects that have

formats and contents that are understandable among them, albeit not necessarily agreed-upon up front.

Drawing on semiotics theory and its recent application to knowledge boundaries (Carlile 2002; Carlile 2004a), we suggest three different levels of knowledge representation: syntactic, semantic, and pragmatic. Knowledge representation at the syntactic, semantic, and pragmatic levels has a one-to-one correspondence to syntactic, semantic, and pragmatic levels of knowledge boundaries in Carlile's framework (2002; 2004b). The knowledge that generates innovation within a function can become a barrier across functions. This is because "knowledge boundaries" between functions are not well understood and proper measures to counter the problems due to knowledge boundaries are not established across the functions (Carlile 2002). The ultimate purpose of knowledge representation is to transfer the represented knowledge beyond the boundaries of functions and firms. Thus, the knowledge representation problem needs to be addressed with regard to examining the phenomena that occur related to knowledge boundaries across functions and firms.

At the syntactic level, interests lie in developing a common syntax, taxonomy, and storage and retrieval technologies, for knowledge sharing among the actors involved. At the semantic level, knowledge representation is focused on developing boundary objects with common meaning, cross-functional interactions/teams, and boundary spanners/translators. At the pragmatic level, efforts lie in developing prototyping and other kinds of boundary objects that can provide a concrete means of representing different interests/pragmatics and facilitating their negotiation and transformation. Table 1 shows three levels of knowledge boundaries, their boundary objects, and the

characteristics of these boundary objects. Most of the boundary objects in Table 1 are IT-enabled. A repository is an example of a boundary object at the syntactic level of knowledge representation. Examples of boundary objects at the semantic level of knowledge representation include standardized forms and methods. Prototypes, and computational models and simulations are examples of boundary objects at the pragmatic level.

Table 1. Three Levels of Knowledge Boundaries (Adapted from Carlile (2002))

Knowledge Boundaries	Boundary Objects	Characteristics of Boundary Objects
Syntactic	• *Repositories*: - Relational databases - Data transfer standards	• Representing
Semantic	• *Standardized forms and methods*: - Structured and semi-structured digital documents with defined meaning - Unstructured digital objects with rich information - Printed documents	• Representing • Learning
Pragmatic	• *Objects or models*: - Virtual prototypes - Software prototypes - Physical prototypes - Computational models and simulations	• Representing • Learning • Transforming

These knowledge representation schemes can be analyzed according to the three relational properties of knowledge at a boundary (Carlile 2002; Carlile 2004a). The first relational property is *difference* in knowledge that refers to a difference in the amount or type of knowledge accumulated between actors. Next is *dependence* that regards the condition in which two actors must take each other into account if they are to meet their goals. This notion of dependence is incorporated into the conceptualization of coordination by Malone and Crowston (1994), which is defined as the management of dependence among activities and resources. We can substitute knowledge for resources to

represent the dependence of knowledge being produced and being used among actors across firm boundaries. The last property is *novelty*, which regards the novelty of the situation between actors and is a function of the novelty of difference and dependence between the actors. Difference, dependence, and novelty are low at the syntactic level, but high at the semantic and pragmatic levels.

Traditionally, researchers have focused on the *syntactic* level of knowledge boundaries. The concept, originated in Shannon and Weaver's (1949) mathematical theory of communication,became the basis of the information processing view (Galbraith 1973; Tushman et al. 1978). At the syntactic level, novelty is low because differences and dependencies between actors are known. Thus, developing a common syntax, taxonomy, and storage and retrieval technologies are sufficient to share and assess knowledge at the boundary. However, a focus at the syntactic level of knowledge boundaries is not enough when novelty increases due to differences and dependencies between the actors involved.

Novelty, due to new situations and requirements, generates interpretive barriers of objects that limit the effective management of knowledge. Thus, we need to consider the *semantic* level of knowledge boundaries that provide an adequate means of sharing and assessing knowledge at a boundary. This view is echoed in the literature that addresses the importance of having a semantic perspective for managing knowledge (Brown et al. 1994; Dougherty 1992; Nonaka 1994).

Finally, given the presence of novelty, difference, and dependence, different interests and incentives arise with existing or new knowledge between the actors. An additional level of boundary objects is required to create common interests and incentives and to deal with negative consequences. At the *pragmatic* level, common pragmatics are

developed for knowledge transformation that refers to a process for the creation of new knowledge, modification of current knowledge, and validation of knowledge. Through common pragmatics, actors can resolve political differences that hinder effective management of knowledge across boundaries.

The creation and management of boundary objects is a key process in developing and maintaining knowledge representation schemes across intersecting actors.

The characteristics of effective boundary objects can be considered at three levels. First, each actor can rely on a shared syntax or language provided by a boundary object to represent its knowledge (Carlile 2002). This shared syntax is the basis for all three levels. Nelson and Cooprider (1996) also mention that building a common language across the actors is the first step in overcoming the informational briefing stage of the IS-line relationship. Second, we can specify and learn about the differences and dependencies of the actors across a given boundary via an effective boundary object at the semantic level. In the case studies described by Carlile (2002), the assembly drawing allowed the actor to specify his concerns about important specifications and critical sealing surfaces, and the challenges of assembling and testing a complex product at high volume. Finally, an effective boundary object at the pragmatic level facilitates joint transformation of knowledge among actors. A common knowledge established at the pragmatic level is used to negotiate and transform knowledge and resolve the different interests among actors. If the actors cannot resolve their current knowledge through negotiation into the objects used, they may have limited influence on problem solving tasks.

2.3.3 Examples of Boundary Objects

2.3.3.1 Syntactic Level Boundary Objects

Boundary objects serve different purposes and the effectiveness of such objects determines the direction and degree of collaborative behaviors across the actors involved. A *shared database* is a boundary object that is created when firms establish a common database based on mutual agreements of information that is accessible across the boundary. This particular boundary object may be managed using a third party model or information hub model (Lee et al. 2000a). In the third party model, a third firm is responsible for collecting and maintaining information in a database for the firms involved. The information hub model has a similar structure to the third party model, but uses a system in lieu of the third firm. The shared database is built on a clear definition of the participants in the beginning and contains agreed-upon syntaxes and contents by the information providers (Soderquist et al. 2000). It becomes a basis for developing routines to improve coordination and communication flows. Thissen and Stam (1992) describe building databases across the relevant actors that is the basis for the integration of information. Such integration of data bases becomes a starting point for cooperation and learning by participating actors. Actors increasingly become aware of the represented knowledge and realize the potential for further cooperation and the need for further knowledge representation.

2.3.3.2 Semantic Level Boundary Objects

A document is a relatively complex object with regard to its structure and use among the participants (Karsten et al. 2001). Researchers have developed very different views

regarding which should be considered a "document" (Buckland 1997). Researchers who pursued the notion of document ended up emphasizing whatever functioned as a document rather than the traditional physical forms of documents (Buckland 1997). It includes texts, spreadsheets, slides, and design drawings in either printed or digital forms. A document is accepted as a boundary object (Levy et al. 1995) after going through several iterations among the participants. After it is approved by the actors involved, it is utilized as a guiding principle of communication and collaboration. Digital documents and supporting digital technologies bring a few critical differences compared with paper documents (Wiederhold 1995). First, they are stored in digital form. Second, they are delivered via electronic methods. Thus, receivers do not need to come to senders. A digital document can be copied to many places and be linked to other relevant documents. Finally, the material is always reproducible from the master version of the work in the digital repository. Some materials in digital forms such as e-books and digital images are fixed while others such as listserv messages, wire service articles, and preprints are changing (Levy et al. 1995). The ease of modification is determined by the level of sophistication of digital technologies. Although digital documents are pervasive and organizational efforts towards digital repositories are enormous, paper documents will exist as the principal medium for communication and interpretation (Levy et al. 1995).

Karsten et al. (2001) investigate the *technical specification* as a boundary object between Valmet, the largest paper machinery supplier in the world, and customer, and as a conscription device in the Valmet project team. As a boundary object, technical specifications provided sufficient common structure, and enough flexibility to allow

different interpretations, thus facilitating the implementation of work in both parties. In their analysis on document interdependencies in a major production system delivery process, Hameri, Nihtila, and Rehn (1999) discovered that technical specifications created by the sales team and a customer was recognized as a key document. Memoranda related to meetings with the customer and layout drawings for key system components were also cited as key documents. An EDI document is a representative example of digital document. An EDI document is a document created by EDI applications following an agreed-upon standard by both trading partners. One of the roles of EDI is to replace paper documents with electronic communications and save costs.

2.3.3.3 Pragmatic Level Boundary Objects

Computer simulation is used to model and simulate complex system behavior before designers build expensive hardware prototypes (Thomke 1998). It enables rich data collection. This data, in turn, may facilitate the development of subsequent experiments. The areas of simulation application are numerous, such as the design of drugs, the design of mechanical products, and the design of electronic products, to name a few. The usefulness of the simulation results are determined by the accuracy of a simulation model given the context and purpose of a simulation.

Prototyping is an approach to building the final product based on a prototype that is partially functional against the actual environment. A prototype is equipped with needed features that can simulate the actual behavior of the product. *Rapid prototyping* provides a method of developing prototypes in a fast and easy way as compared with the traditional prototyping method. It may lead to significant improvements in development time and cost, an advantage considered crucial to achieving competitive advantage in fast

changing market situations (Clark et al. 1991; Clausing 1993; Smith et al. 1991; Wheelwright et al. 1992). Prototyping or rapid prototyping can be applied to construct physical prototypes, virtual prototypes, and software prototypes. *Virtual prototyping* employs information systems to build virtual artifacts, such as components and parts. The virtual prototype is supported by a database, and contains links to all data, information, and codified knowledge that are necessary to deal with an artifact (D'Adderio 2001). The user may use it to digitally simulate the characteristics of the product and the production processes. An example of such a prototype is a 3D Digital Model substituting for solid clay models and paper- or computer-supported sketches.

Software prototyping relies on information systems to build prototypes. The forms of prototyping include "throw-away" design prototypes (e.g., mock-ups and user interface prototypes) prior to specification, specification prototypes of an entire system prior to specification and construction, and design-driven prototypes for a pre-finalization test-drive of a system (Baskerville et al. 1996). Typical software prototyping follows an evolutionary process that starts with design prototypes and is refined until full functionality is achieved after a series of iterative prototype reconstructions (Connell and Schafer 1989). It is reported that the use of software prototyping in the IS development industry has increased from 33% in 1984, to 46% in 1987, to 49% in 1988, to 61% in 1990, and to 71% in 1995 (Beynon-Davies et al. 1999; Hardgrave 1995). The greatest benefit of software prototyping is the improvement in user communication (Beynon-Davies et al. 1999), as it works as a reference point for comprehending and developing requirements among users and developers (Alavi 1984). The participants use the prototype as a meaningful and direct communication platform, thereby reducing

misunderstandings originating from interpretations of abstract specifications (Baskerville et al. 1996).

3. RESEARCH MODEL

We advance a theoretical model that connects the interorganizational design mechanism (i.e., contextual ambidexterity), knowledge representation capability, environmental uncertainty moderator, and relationship performance of interorganizational exploratory and exploitative knowledge sharing (Figure 2). In discussing this model, we first introduce the concept of relationship performance. Second, we present the effects of knowledge sharing and the effects of knowledge sharing emphasis on relationship performance. Third, we discuss the effects of the interorganizational design mechanism on knowledge sharing. Fourth, we examine the moderating effects of knowledge representation capability on the interorganizational design mechanism-knowledge sharing link. Finally, we discuss the moderating effects of environmental uncertainty on knowledge sharing and relationship performance. Tables 2 and 3 summarize the construct definitions and their related hypotheses.

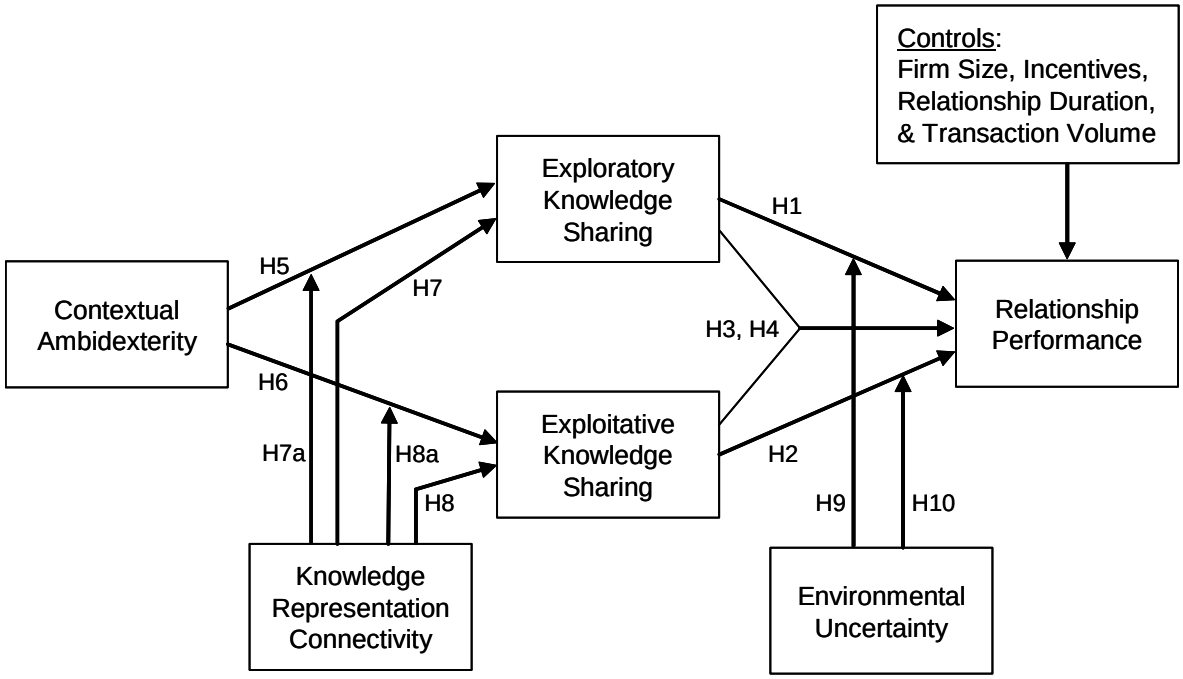

Figure 2. Research Model

Table 2. Construct Definition and Selected Prior Literature

Construct	Definition	Selected Prior Literature
Relationship Performance	The extent to which the partners consider their relationship worthwhile, equitable, productive, and satisfying.	Van de Ven et al. (1976); Ruekert and Walker (1987); Selnes and Sallis (2003)
Exploratory Knowledge Sharing	The exchange of knowledge between firms in a long-term relationship seeking long-run rewards, focusing on the survival of the system as a whole, and pursuing risk-taking behaviors.	Levinthal and March (1993); Ghemawat and Costa (1993)
Exploitative Knowledge Sharing	The exchange of knowledge between firms and associated with short run rewards by focusing on the survival of the components of the system and pursuing risk-averse behaviors.	Levinthal and March (1993); Ghemawat and Costa (1993)
Contextual Ambidexterity	The behavioral capacity of an interorganizational relationship that allows for the simultaneous achievement of alignment and adaptability.	Gibson and Birkinshaw (2004)
Knowledge Representation Connectivity	The level of reliance on boundary objects as a platform for knowledge sharing across firm boundaries.	Star and Griesemer (1989); Carlile (2002; 2004a); Carlile and Rebentisch (2003)
Environmental Uncertainty	An individual's perceived inability to predict an organization's environment accurately.	Milliken (1987); Selnes and Sallis (2003); Moorman and Miner (1997)

Table 3. Hypotheses and Selected Prior Literature

Key Determinants	Hypotheses	Selected Prior Literature
Exploratory Knowledge Sharing	H1: The greater the exploratory knowledge sharing in an interorganizational relationship, the greater the relationship performance.	Daft and Lengel (1986); Koka and Prescott (2002); Cassiman and Veugelers (2002)
Exploitative Knowledge Sharing	H2: The greater the exploitative knowledge sharing in an interorganizational relationship, the greater the relationship performance.	
	H3: Relationships with a dual emphasis on exploitative and exploratory knowledge sharing show smaller intra-group variations in relationship performance, relative to their mean values of performance, than relationships with an emphasis on exploratory knowledge sharing.	He and Wong (2004)
	H4: Relationships with an emphasis on exploratory knowledge sharing lead to larger intra-group variations in relationship performance, relative to their mean values of performance, than relationships with an emphasis on exploitative knowledge sharing.	
Contextual Ambidexterity	H5: The greater the contextual ambidexterity in an interorganizational relationship, the greater the exploratory knowledge sharing in the relationship.	Gibson and Birkinshaw (2004)
	H6: The greater the contextual ambidexterity in an interorganizational relationship, the greater the exploitative knowledge sharing in the relationship.	
Knowledge Representation Connectivity	H7: The greater the knowledge representation connectivity, the greater the exploratory knowledge sharing in the relationship.	Winter (1987); Nonaka (1994); Zander and Kogut (1995); Schulz (2001); Zollo and Winter (2002)
	H7a: The greater the contextual ambidexterity associated with high levels of knowledge representation connectivity, the greater the exploratory knowledge sharing in the relationship.	
	H8: The greater the knowledge representation connectivity, the greater the exploitative knowledge sharing in the relationship.	
	H8a: The greater the contextual ambidexterity associated with high levels of knowledge representation connectivity, the greater the exploitative knowledge sharing in the relationship.	
Environmental Uncertainty	H9: The higher environmental uncertainty associated with greater levels of exploratory knowledge sharing, the greater the relationship performance.	Ozsomer and Gencturk (2003)
	H10: The lower environmental uncertainty associated with greater levels of exploitative knowledge sharing, the greater the relationship performance.	

3.1 Relationship Performance

Relationship performance refers to the extent to which the partners consider their relationship worthwhile, equitable, productive, and satisfying (Ruekert et al. 1987; Selnes et al. 2003; Van de Ven et al. 1976). We consider relationship performance to encompass both relationship effectiveness and efficiency (Selnes et al. 2003). Relationship effectiveness is defined as the degree to which an interorganizational relationship achieves success of products and programs within the relationship vis-à-vis that of its competitors in the market (Ozsomer et al. 2003). Relationship efficiency is defined as to the degree to which an interorganizational relationship leads to successful outcomes with regard to resources employed in implementing them (Ozsomer et al. 2003).

Relationship performance is suggested to be a function of a mix of exploratory and exploitative knowledge sharing activities. A high performing relationship exists when both parties in the relationship achieve effectiveness and efficiency (Selnes et al. 2003). The results of exploratory knowledge sharing may lead not only to long-term benefits through the discovery of new profitable businesses via new knowledge, but also to short-term benefits through the application of new discoveries and experiments. Exploitative knowledge sharing may bring operational efficiency to the relationship as well as strategic benefits by controlling relational resources to be used more effectively.

Overall, the literature supports the association of effectiveness (e.g., Dyer and Singh (1998); Selnes and Sallis (2003); von Hippel (1998)) and efficiency (e.g., Heide and Stump (1995); Selnes and Sallis (2003)) with relationship learning. As two firms engage in high learning relationships, they are more likely to better understand each other's needs (Kalwani and Narayandas 1995) and produce high-valued and superior products and

services (von Hippel 1994; von Hippel 1998) which lead to relationship effectiveness. On the other hand, firms in high learning relationships are likely to reduce transaction costs because they improve coordination with each other and are familiar with the products they have developed together (Selnes et al. 2003), which leads to relationship efficiency.

3.2 The Effects of Knowledge Sharing on Relationship Performance

We expect that a high level of knowledge sharing leads to high relationship performance as learning generally increases average performance (Levinthal et al. 1993: 106). Knowledge sharing fosters an understanding and appreciation between firms for products, technologies, markets, and processes that affect their relationship performance (Nelson et al. 1996). This mutual understanding and appreciation are likely to increase the degree to which firms share a vision of product, technology and marketing strategy design and implementation (Moorman 1995; Senge 1990; Sinkula 1994).

Specifically, high levels of exploratory knowledge sharing may lead to greater relationship performance by reducing uncertainties about markets, customers, and technological changes. As knowledge increases, uncertainty, that is, the absence of knowledge, decreases (Daft et al. 1986). A greater amount of knowledge increases the availability of knowledge and new ideas (Sheremata 2000). This, in turn, enables organizations to more effectively identify market opportunities and the possibilities and threats of new products (Moorman 1995). The product development literature shows that more knowledge is related to positive innovation outcomes (Brown et al. 1997). It

emphasizes that frequent knowledge flow (both internal and external) leads to successful product development outcomes (Ancona et al. 1992).

In addition, exploratory knowledge is likely to raise the creative potential of the relationship (Rodan et al. 2004), and lower the risk of lock-in with inferior technologies (Levinthal et al. 1993). This is because shared knowledge strengthens assimilative power and enables novel associations and linkages of relationships (Cohen et al. 1990; Rodan et al. 2004). Simon (1985) also points out that diverse knowledge structures coexisting in the same mind foster learning and problem solving that yield innovation. This subsequent innovation is known to enhance performance (see Koka and Prescott (2002); Rodan and Galunic (2004); Wuyts et al. (2004)). Knowledge diversity also helps the implementation of new ideas, specifically, of multifaceted or complex tasks. Baum, Calabrese, and Silverman (2000) report that networks that provide access to more diverse knowledge raised rates of revenue and R&D spending, growth, and patenting. Specifically, network configuration had a powerful effect on startups' rate of patenting. Hargadon and Sutton (1997) also explain how a California-based product development company, IDEO, consciously attempts to leverage heterogeneity of knowledge in the generation of new ideas. Overall, the product development literature supports the findings that comprehensive internal and external communication (Ancona et al. 1992; Imai et al. 1985) and cross-functional perspective sharing help innovation (Clark et al. 1987; Cohen et al. 1990).

Higher levels of exploitative knowledge sharing are likely to improve relationship performance by reducing coordination costs such as inventory and monitoring costs between the partners (Bakos 1991; Klein 2003). Williamson (1985) argues that firms that

engage in frequent, recurring transactions can afford to generate relational rents by adopting more specialized and complex governance structures. Greater knowledge sharing allows the reduction of search costs, and makes knowledge more reliable and available earlier while at a shorter distance to the firms in the relationship (Burt 1992; Koka et al. 2002). These benefits lead to increases in efficiency and productivity (Levinthal et al. 1993).

Additionally, exploitative knowledge sharing that encompasses the three dimensions of learning (i.e., temporal, spatial, and failure myopia) is likely to improve the probability of new opportunity recognition and thus the ability to perform routine ongoing tasks (Koka et al. 2002; Rodan et al. 2004). Diverse information or knowledge is likely to promote the discovery of new opportunities and resources more quickly. This early opportunity recognition helps prompt the repositioning of local strategies and improves a project's performance with respect to the execution of ongoing tasks.

Knowledge sharing could have adverse consequences, however, when firms suffer information and knowledge overload (Koka et al. 2002). Firms may rely too heavily on current knowledge and neglect the acquisition of new knowledge. This practice may have negative consequences as a result of unanticipated environmental uncertainty (Levinthal et al. 1993). Taken together the above discussion proves:

H1: The greater the exploratory knowledge sharing in an interorganizational relationship, the greater the relationship performance.

H2: The greater the exploitative knowledge sharing in an interorganizational relationship, the greater the relationship performance.

3.3 The Effects of Knowledge Sharing Emphasis on Performance

We expect that relationships will generate varying levels of relationship performance depending on whether the emphasis is on a dual knowledge sharing, either exploratory or exploitative, or neither approach. *A dual emphasis* refers to the relationship that has both high exploratory and exploitative knowledge sharing. We suggest that a dual emphasis in long-term interorganizational relationships leads to higher relationship performance than when the emphasis is placed on either exploratory or exploitative or neither.

In developing our hypotheses, we considered both performance and its variability because learning is known to influence performance variance as well as performance means (He et al. 2004; March 1991). Drawing on He and Wong (2004), we expect that relationships with a dual emphasis on knowledge sharing will exhibit a lower intra-group variance-to-mean performance ratio than relationships with emphasis on exploratory knowledge sharing. Relationships that emphasize exploratory knowledge sharing are expected to show a greater intra-group variance-to-mean performance ratio than those that emphasize exploitative knowledge sharing.

Regarding dynamic interactions between exploration and exploitation toward performance, Gavetti and Levinthal (2000) reported that most of the performance enhancement results from the slow but steady improvement in the experiential search (i.e., exploitation) effort. Cognitive search (i.e., exploration), on the other hand, results in a powerful suggestion for an organization's initial strategy choice, as well as a useful guideline on subsequent efforts at experiential search. Although an experiential search leads an organization to achieve a local peak in the performance landscape, cognitive

search helps identify superior local peaks. Thus, the joint search efforts generate synergies toward achieving superior peaks.

In our research context, exploratory knowledge sharing can support exploitative knowledge sharing in that new knowledge about products and processes can provide insights to improve current products and processes and thus help alliances move to a more optimum level. Similarly, exploitative knowledge sharing enhances the effect of exploratory knowledge sharing because it allows us to examine the practicality of new knowledge based upon that which has been previously successful and possible. Thus, the results of the joint sharing of exploratory and exploitative knowledge are likely to lead to reliable and superior relationship performance.

Gavetti and Levinthal (2000) also described how cognitive search invokes a broad set of alternatives, both local and distant, and plays a greater role in enhancing the initial adaptive behavior. Cognitive search helps organizations immediately identify the peak on the performance landscape. Although this cognitive peak results in a payoff that is better than the level obtained from random search, this payoff is still lower than the potential level that can actually be accomplished, possibly with the combination of experiential search. In addition, we suggest that cognitive search alone is likely to yield payoffs that are more rugged or multi-peaked (i.e., more variation) than the level of payoffs that can be achieved via the joint cognitive and experiential search. This is because the actual payoff landscape is complex and the results of cognitive search can be crude and volatile, if not supported by experiential search that provides slow but steady improvement.

Experiential search maneuvers offer alternative on the neighborhood of current activity through local experimentation. Search is local in that only one element in a

search space is varied at a time. Given the search space, organizations engage in experiential search to identify a local peak. Organizations either find a local peak or initiate a new local search at its prior starting point, when the performance declines. The results of a series of experiential searches are likely to yield performances that are reliable. Summarizing the above discussions, we propose:

> *H3: Relationships with a dual emphasis on exploitative and explorative knowledge sharing shows smaller intra-group variation in relationship performance, relative to their mean values of performance, than relationships with an emphasis on explorative knowledge sharing.*
>
> *H4: Relationships with an emphasis on explorative knowledge sharing leads to larger intra-group variation in relationship performance, relative to their mean values of performance, than relationships with an emphasis on exploitative knowledge sharing.*

3.4 The Effects of Contextual Ambidexterity on Knowledge Sharing

How can firms maintain exploration or exploitation activities simultaneously and prevent relationships from skewing toward either activity? We suggest contextual ambidexterity as the interorganizational design mechanism that can enable both types of knowledge sharing. *Contextual ambidexterity* is defined as the behavioral capacity of an interorganizational relationship to allow for the simultaneous achievement of alignment and adaptability (Gibson et al. 2004). The context is broadly defined as the set of systems, processes, and beliefs that influence the behaviors of individuals involved in the relationship.

Alignment refers to coherence among all the patterns of activities in the relationship that are geared toward the same goals. In contrast, *adaptability* regards the capacity to reconfigure activities in the relationship quickly to meet changing requirements of the

business environment. Contextual ambidexterity is the non-substitutable combination (i.e., interaction) of alignment and adaptability. Our conceptualization of contextual ambidexterity draws on the earlier conceptualization at the firm level (Gibson et al. 2004), and is extended to interorganizational relationships to explain how relationships can respond to paradoxical requirements.

We consider ambidexterity to be a powerful approach to manage the paradox and to foster exploration and exploitation. Ambidexterity refers to an organization's ability to conduct two paradoxical activities at the same time by requiring the organization and its people to have two heterogeneous, but related, skills simultaneously (Gibson et al. 2004). Researchers have consistently reported the importance of maintaining paradoxical activities, including efficiency and flexibility (Adler et al. 1999), static and dynamic efficiency (Ghemawat et al. 1993), and search and stability (Rivkin et al. 2003; Siggelkow et al. 2003), for example. The notion of ambidexterity is becoming crucial because turbulent business environments require firms and their people to have simultaneous heterogeneous, but related, skills for survival. According to Hewlett-Packard's top software executive, IT professionals need to be aware of new trend of business realities in which "success is measured by the ability to innovate, and not by being able to solve problems as they arise" (Dunn 2004). Thus, organizations are constantly embroiled in tensions caused by the pressure of responding effectively to paradoxical requirements.

The ambidexterity lens can offer a potentially powerful framework for examining the phenomena of plurality described above, in general, and exploration and exploitation, in particular. In the context of our investigation, the ambidexterity mechanism refers to the

organizational design established to conduct the exploration and exploitation in a relationship. An ambidextrous organizational design is required to achieve the simultaneous existence of exploration and exploitation in an interorganizational relationship.

Researchers have suggested two different ambidexterity mechanisms, namely structural ambidexterity and contextual ambidexterity, to explain the paradox. Traditionally, researchers have focused on *structural ambidexterity,* in which dual organizational structures must be established to support exploration and exploitation. Organizational structure is an important factor for explaining exploration and exploitation activities (Schoonhoven et al. 1990). Structure influences coordination of individuals and subgroups in the organization (Milgrom et al. 1992), its communication processes (Guetzkow 1965), and its problem-solving behavior (Lawrence et al. 1967; Thompson 1967). From the perspective of structural choices, which enable knowledge sharing capabilities, it is important to recognize that tasks, processes, and culture are consistent within subunits, but heterogeneous across subunits. Accordingly, Benner and Tushman (2003) suggest ambidextrous, or organizational, forms as an organizational structure choice in order to achieve both exploration and exploitation, as they simultaneously build in the necessary tight coupling with subunits and loose coupling across subunits. Structural ambidexterity entails establishing: 1) distinct tightly coupled designs for exploration and exploitation and 2) loosely coupled designs between these tightly coupled structures (Benner et al. 2003).

Traditionally, organizational researchers have emphasized structural ambidexterity mechanisms to manage contradiction (Benner et al. 2003; Duncan 1976). In this research

we do not focus on structural ambidexterity for the following reasons: 1) although opportunities for relational learning can influence the structure of interorganizational relationships, the structural choice of relationships can be determined by other factors, such as inter-firm contracts, other alliance partners, and alliance transaction histories, etc.; and 2) it can be more challenging to build the complex structural mechanisms across firm boundaries than it is within a single firm. Instead, we suggest that contextual schemes are an effective and viable means of resolving contradictions in the context of interorganizational relationships. Contextual schemes are easier to implement than interorganizational structural mechanisms. Contextual schemes can also be more effective in fostering knowledge sharing because they can directly empower participating entities in the relationships.

For example, take a few firms that exemplify how business contexts can effectively shape individuals' behaviors for innovation: Intel adds a new fabrication facility to its operations about every nine months; 3M established a goal to generate 30 percent of its revenues from products introduced in the most recent five-year period; and British Airways rehashes its service classes every five years (Eisenhardt et al. 1998). The reason for the success at each of these firms lies in each firm's ability to rejuvenate its people by establishing a behavioral context that triggers individuals to learn new things and innovate themselves without losing focus on ongoing tasks (Bartlett et al. 1995). The business context is as pervasive and influential as is its climate in stimulating people inside the organization.

"Time pacing" is an example of an explicit strategy that becomes a basis for contextual ambidexterity. It is a strategy that introduces change at predictable time

intervals to compete in a turbulent market environment (Eisenhardt et al. 1998). Intel is one of the leading practitioners of this strategy. It is regular, rhythmic, and proactive in its introduction of new products or services according to the calendar. Time pacing causes an enormous psychological impact (Eisenhardt et al. 1998). Individuals feel a relentless sense of urgency for the given deadlines and are required to synchronize the speed and intensity of their efforts to the common goals. Thus, people become focused and efficient about the task at hand, while also continuously innovating themselves to fulfill new requirements.

We argue that contextual ambidexterity in a long-term relationship should promote both exploratory and exploitative knowledge sharing. Alignment increases behavioral consistency among individuals in the relationship and results in efficiency on the execution of routines. Highly aligned relationships will enable individuals to efficiently perform existing businesses across the boundaries. Adaptability allows individuals to maintain their deviant beliefs and encourages them to experiment with new ideas. This, in turn, will lead to the pursuit new ideas in relationships. Therefore, by combining alignment and adaptability, contextual ambidexterity should promote sharing of both types of knowledge. Thus:

H5: The greater the contextual ambidexterity in an interorganizational relationship, the greater the exploratory knowledge sharing in the relationship.

H6: The greater the contextual ambidexterity in an interorganizational relationship, the greater the exploitative knowledge sharing in the relationship.

3.5 The Moderating Effects of Knowledge Representation Connectivity

Information technology (IT) can facilitate exploratory and exploitative knowledge sharing across firm boundaries by spanning knowledge boundaries and establishing a shared knowledge representation platform. Knowledge representation refers to the codification of a firm's knowledge in the form of objects that can be shared among the parties involved. Our conceptualization of knowledge representation is similar to knowledge codification (Zollo et al. 2002). However, we are not concerned with objects that cannot be shared by the partners involved.

In this research, we specifically focus on *digital boundary objects* (Star et al. 1989) as a core element of knowledge representation. Traditionally, researchers have investigated non-digital boundary objects. However, the importance of IT and digital boundary objects associated with IT have been increasing as an essential means of interorganizational collaboration (Levina et al. 2005; Malhotra et al. 2005; Pawlowski et al. 2004). We consider digital boundary objects at syntactic, semantic, and pragmatic levels of a whole to contribute to knowledge representation in the relationship. Based on the conceptualization of knowledge representation, we define *knowledge representation connectivity* as the level of reliance on boundary objects as a platform for knowledge sharing across firm boundaries.

We argue that the relationship between contextual ambidexterity and knowledge sharing is influenced by knowledge representation connectivity. Following accepted methodological procedures (Sharma et al. 1981), we simultaneously posit direct and

quasi-moderating effects of knowledge representation connectivity in relation to contextual ambidexterity and knowledge sharing. We expect that knowledge representation connectivity has positive direct effects on knowledge sharing (Nonaka 1994; Schulz 2001; Winter 1987; Zander et al. 1995). First, knowledge representation may be used as a vehicle for integrating technologies in different places (Allen et al. 1991) and by people scattered within and across firms (Bechky 2003; Bodker 1998). Allen et al. (1991) point out the availability of common objects or representations as one of the most important reasons for the successful integration of new technologies in separate workplaces. Knowledge representation may also be used to mediate the relations between designers within a firm, between designers across firms, and between design teams and future users of the product (Bodker 1998). Second, the formalisms applied in representing knowledge can be used to open communication across boundaries (Floyd 1987) and thus facilitate knowledge sharing (Pondy 1978). These formalisms establish a shared syntax, or language, at the syntactic level; provide a concrete means to specify and learn about differences and dependencies at the semantic level; and facilitate a process where firms can jointly transform their knowledge at the pragmatic level (Carlile 2002). Third, knowledge representation may be used to mitigate the hazardous effects of heterogeneity of task experiences (Zollo et al. 2002). Task heterogeneity refers to the variance in the characteristics of the task presented in different contexts. Task heterogeneity makes inferences much more difficult and may lead to the generation of inappropriate generalizations and poorer performance (Cormier et al. 1987; Gick et al. 1987; Holland et al. 1986; Holyoak et al. 1995). Knowledge representation may reduce the hazards of inappropriate generalizations because it allows us to uncover the

interdependence between the heterogeneity and the action-performance relationships (Zollo et al. 2002). Finally, knowledge representation may reduce the degree of causal ambiguity between the actions and performance outcomes of the task (Simonin 1999; Zollo et al. 2002). The reduced causal ambiguity helps facilitate knowledge sharing.

The IT literature emphasizes facilitating roles of digital boundary objects in fostering knowledge sharing. Researchers report that confounding, or the lack of, standards concerning content and definition of data and information transferred between parties is the primary reason for the slow diffusion of Electronic Data Interchange (EDI), which results in a low volume of information and knowledge processing activities (Payton 2000; Thissen et al. 1992; Tuunainen 1999). The literature also recognizes that there are not only problems in the transfer and interpretation of objects, but also in the deficiency of objects to serve different purposes (Thissen et al. 1992).

Next, we posit that knowledge representation connectivity moderates the relationship between contextual ambidexterity and exploratory and exploitative knowledge sharing. The facilitating conditions of knowledge sharing, enabled by contextual ambidexterity, are amplified by the presence of high levels of knowledge representation connectivity. The potentiality of the interorganizational design mechanism toward knowledge sharing may be properly exercised when the represented knowledge become a proper medium of discourse across the partners. The existence of the schemes between the partners involved provides concrete means, forms, and templates to express the knowledge they have and want to transfer. Thus given the templates, they can easily share their knowledge by taking advantage of existing syntax and semantics without reinventing the wheel.

A key characteristic of represented knowledge in boundary objects is that they can be put to a variety of uses. For example, data transfer standards can be used to automate and standardize existing processes for data transfer between firms. These standards can also be used to design new and emerging processes for data transfer that supports new business opportunities across firm boundaries. Specifically, we first suggest that knowledge representation connectivity influences the way contextual ambidexterity affects exploratory knowledge sharing. Knowledge representation is relevant to exploratory knowledge sharing as it is flexible enough to accommodate syntax, semantics, and pragmatics for new and emerging activities and thus forms discourse surrounding new products, processes, and services across partners. Exploratory knowledge requires distance search (Benner et al. 2002) and consists of rich and complex knowledge across the parties. Knowledge representation connectivity can provide a basis for rich and complex knowledge sharing.

We also expect knowledge representation connectivity to determine the impact of contextual ambidexterity on exploitative knowledge sharing. In an exploitative mode, knowledge representation relies on existing knowledge that is stable and not changing rapidly (Eisenhardt et al. 2000). In this context, knowledge representation is required to gather specific knowledge that will provide deeper knowledge in a particular area, which in turn enables incremental innovation (Rowley et al. 2000). Knowledge representation can be easily customized to support established and recurrent activities so that exploiters are better connected for in-depth analyses in specific areas of interest. A strong connectivity of existing knowledge via boundary objects can be a foundation for sharing and accessing exploitative knowledge between partners. Thus,

H7: The greater the knowledge representation connectivity, the greater the explorative knowledge sharing in the relationship.

H7a: The greater the contextual ambidexterity associated with high levels of knowledge representation connectivity, the greater the explorative knowledge sharing in the relationship.

H8: The greater the knowledge representation connectivity, the greater the exploitative knowledge sharing in the relationship.

H8a: The greater the contextual ambidexterity associated with high levels of knowledge representation connectivity, the greater the exploitative knowledge sharing in the relationship.

3.6 The Moderating Effects of Environmental Uncertainty

We focus on one dimension of environmental context: environmental uncertainty. Environmental uncertainty is concerned with the external environment outside the dyad boundary. We posit that exploratory knowledge sharing can enhance relationship performance under high environmental uncertainty, whereas exploitative learning is appropriate for low environmental uncertainty. The literature suggests that the importance of exploratory and exploitative learning varies with environmental uncertainty (Ghemawat et al. 1993; Levinthal et al. 1993: 107; Ozsomer et al. 2003). That is, the linkage between exploratory and exploitative learning and relationship performance depends on environmental uncertainties surrounding firms.

Environmental uncertainty is defined as "an individual's perceived inability to predict [an organization's environment] accurately" (Milliken 1987). This definition is used to mean "state" uncertainty. That is, managers experience state uncertainty for the perceived environment, or recognize a particular component of that environment to be unpredictable. Organizational researchers consider environmental uncertainty an important variable in the explanation of performance (see Jauch and Kraft (1986)). For example, environmental uncertainty has typically been used as a contingency variable in

the explanation of the effect of strategy and structure decisions on performance (e.g., Damanpour (1996)). One example argument related to structure decisions is the following: bureaucratic structures can lead to high performance under low environmental uncertainty whereas organic structures are suitable for high environmental uncertainty (Lawrence et al. 1967; Mintzberg 1979). We focus on state uncertainties associated with two components of the environment (Jaworski et al. 1993): market turbulence and technological turbulence. Market turbulence refers to the rate of change in the composition of customers and their preferences (Jaworski et al. 1993), while technological turbulence regards the degree of change associated with new product technologies (Glaser et al. 1993; Jaworski et al. 1993; Weiss et al. 1993).

We expect interorganizational relationships to be effective with exploratory knowledge sharing under high environmental uncertainties. Under high environmental uncertainties associated with the two components, firms that are involved in more experimental, flexible, and even improvisational, activities should be successful (Scott 1992). These activities require new, emerging knowledge (Eisenhardt et al. 2000). Exploratory knowledge sharing between firms can help solve problems that emerge during such activities. The firms can appropriate shared exploratory knowledge for creating prototypes, and generating and evaluating alternatives.

We expect exploitative knowledge sharing to make interorganizational relationships efficient under low environmental uncertainties. When uncertainties are low, firms can plan and organize their activities, and rely on existing knowledge (Eisenhardt et al. 2000) to conduct these activities. Under low uncertainties, product development is a predictable series of steps that can be compressed. Firms can plan development, simplify through

supplier involvement, shorten the time it takes to complete each step in the development process, and overlap development steps (called compression strategy, see Eisenhardt and Tabrizi (1995)). Existing knowledge becomes the basis for exercising compression strategy that can lead to yielding predictable outcomes.

However, exploitation can be a major disadvantage as it can create core rigidities, that is, inappropriate sets of knowledge (Leonard-Barton 1992), in the face of high environmental uncertainty (Eisenhardt et al. 2000). Even seemingly minor innovations or changes can weaken the usefulness of existing knowledge (Henderson et al. 1990). Even worse, the advantage of existing competencies can be destroyed due to environmental changes like technological discontinuities (Tushman et al. 1986). In Leonard-Barton's study, the new workstation project of Electronics was less than optimal because the traditional focus on producing an excellent hardware was not aligned with developing supporting software applications (Leonard-Barton 1992). Hardware development knowledge was available through well-worn channels, but application software development knowledge did not exist. This discussion leads to the following hypotheses:

H9: The higher environmental uncertainty associated with greater levels of exploratory knowledge sharing, the greater relationship performance.

H10: The lower environmental uncertainty associated with greater levels of exploitative knowledge sharing, the greater relationship performance.

4. RESEARCH DESIGN AND DATA COLLECTION

4.1 Research Context

The empirical context for this research is the logistics industry in the United States. The unit of analysis is the relationship between a vendor business unit and a customer business unit for a major supply chain service. We used a matched pair sampling strategy to collect data from the perspective of the vendor and its customers. Our research setting is SupplyChainCo (a focal firm), one of the world's largest supply chain solutions vendors, and its relationships with customers for one of the two supply chain services it offers: freight services and logistics services. Freight services refer to the physical transportation of goods in any pallet or packaging configuration via air, ocean, road, or rail while logistics services regard the flow and storage of goods, funds, and related information from point-of-origin to point-of-consumption.

Testing of our research model required the presence of both exploitation and exploration activity in relationships. Logistics is primarily concerned with the physical distribution of raw materials and finished products (Slack et al. 1999). It was traditionally recognized as secondary to functional areas such as marketing and production, but has been gradually recognized as a critical factor of competitive advantage (Bowersox et al. 1996; Bowersox et al. 1995). Today, logistics providers offer a wide range of services in purchasing, distribution, inventory management, packaging, manufacturing, and even customer service (Bowersox et al. 1996; Titone 1996). The impetus for the expansion of the logistics industry arises from the needs of firms to access global markets, to realize greater operational efficiencies, and to achieve technological competencies (Cooper et al.

1993; Fawcett et al. 1993). This industry is under continuous pressure to innovate while still efficiently performing the traditional business lines, such as the physical distribution of materials and products. Thus, the logistics industry meets the testing requirements for our research model.

4.2 Sample

Data were collected using an online survey that measured all variables from the perspective of the customer as well as the vendor (Table 4). First, we collected measures of all variables from customer business units using key informants who are highly knowledgeable about the phenomena. For those customers who responded to the survey, the corresponding account managers at SupplyChainCo provided matched data. Customers are managed through two divisions at SupplyChainCo: freight and logistics, and freight only. The freight and logistics division has a mix of freight and/or logistics services and the freight only division handles freight services. Despite their similarities, these are two separate divisions given their origins in different corporations that later merged.

Table 4. Sample Profile

	Customer			Vendor
Services	Account Manager	Call Center	Total	
Freight & Logistics	97	25	122	43
Freight Only	74	42	116	33
Total	171	67	238	76

Our customer sample was 4208 SupplyChainCo relationships for the two classes of services. We first sent a pre-letter to screen customers for eligibility, to locate a key

informant, and to avoid an abrupt, unexpected survey. The initial customer sample was narrowed down to 3379 target relationships for the purpose of the survey.

A first e-mail was sent to customer informants three weeks after the pre-letter, which was followed by a second reminder e-mail. To enhance the response rate, we offered an incentive in the form of an executive summary of our findings. The two waves of the survey resulted in a total of 331 responses, for an overall response rate of 10 percent. To probe into the low response rate, we asked 30 randomly selected informants to provide reasons for not responding to the survey. The major reasons, ranked in order, include (1) very little business at this time, (2) disappointment at the service, (3) a busy period, (4) survey not being applicable, and (5) company policy. Of the 331 responses received, we discarded 93 due to an excessive amount of missing information. The final usable sample from customers consisted of 238 surveys. Of the 238 relationships with SupplyChainCo, 171 have been managed by dedicated account managers and the rest have been handled by a shared call center. After customer data collection was complete, the SupplyChainCo account managers dedicated to the relationships were asked to provide matched data. This resulted in a total of 81 responses, for a response rate of 47 percent. We eliminated 5 of these responses due to excessive missing information, yielding 76 usable surveys from the vendor side.

According to the North American Industry Classification System (NAICS), the major industry categories included in our customer sample are manufacturing (67% of the customer sample); wholesale trade (12%); professional, scientific, and technical services (5%); and retail trade (4%) (Table 5). Specifically, the manufacturing category (NAICS code 31-33) has a wide range of customers, ranging from low uncertain industries (e.g.,

fabricated metal product manufacturing) to high uncertain industries (e.g., computer and electronic product manufacturing).

Non-response bias was assessed by comparing data from early and late survey respondents (Armstrong et al. 1977). The final sample from the customers includes 55 percent of the responses in the first wave and 45 percent in the second wave. The ANOVA tests revealed no significant differences between the two groups on any of the independent variables. The same approach was used to evaluate non-response bias with the vendor data. In the final sample from SupplyChainCo 43 percent of the responses were from the first half of responses and 57 percent from the second half. No significant differences across key independent variables were detected across the two groups. Taken together, these results suggest that non-response bias is not a problem in our data.

Table 5. NAICS Titles of Customers

Code	NAICS Title	Frequency
11	Agriculture, Forestry, Fishing and Hunting	1
21	Mining	1
31-33	Manufacturing	
311	Food Manufacturing	2
313	Textile Mills	3
315	Apparel Manufacturing	4
316	Leather and Allied Product Manufacturing	3
321	Wood Product Manufacturing	2
322	Paper Manufacturing	1
323	Printing and Related Support Activities	1
325	Chemical Manufacturing	18
326	Plastics and Rubber Products Manufacturing	2
327	Nonmetallic Mineral Product Manufacturing	2
331	Primary Metal Manufacturing	5
332	Fabricated Metal Product Manufacturing	9
333	Machinery Manufacturing	27
334	Computer and Electronic Product Manufacturing	31
335	Electrical Equipment, Appliance, and Component Manufacturing	8
336	Transportation Equipment Manufacturing	24
337	Furniture and Related Product Manufacturing	4
339	Miscellaneous Manufacturing	14
42	Wholesale Trade	
423	Merchant Wholesalers, Durable Goods	22
424	Merchant Wholesalers, Nondurable Goods	6
44-45	Retail Trade	
441	Motor Vehicle and Parts Dealers	1
442	Furniture and Home Furnishings Stores	1
444	Building Material and Garden Equipment and Supplies Dealers	1
448	Clothing and Clothing Accessories Stores	1
451	Sporting Goods, Hobby, Book, and Music Stores	1
452	General Merchandise Stores	1
454	Nonstore Retailers	3
48-49	Transportation and Warehousing	
488	Support Activities for Transportation	1
493	Warehousing and Storage	1
51	Information	
511	Publishing Industries (except Internet)	1
517	Telecommunications	3
518	Internet Service Providers, Web Search Portals, and Data Processing Services	1
52	Finance and Insurance	
522	Credit Intermediation and Related Activities	2
523	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	1
54	Professional, Scientific, and Technical Services	12
56	Administrative and Support and Waste Management and Remediation Services	1
81	Other Services (except Public Administration)	2
92	Public Administration	3
Not Identified		11
Total		238

4.3 Instrument Development

In developing questionnaires for the customer and the vendor we adapted existing measures to our research context, when possible. We also created measures where existing scale items did not exist (i.e., exploratory and exploitative knowledge sharing, and knowledge representation connectivity). The questionnaires were first refined through five pilot tests, using a policy-capturing method with part-time working students at the graduate and advanced undergraduate levels at a major university in the southeastern United States (Appendix A). This refined version was subsequently reviewed by colleagues and by a sample of ten senior managers of the vendor to verify the clarity of instructions, appropriateness of terminology and item-wording, and response formats and scales.

4.4 Measures

We operationalized the key variables using multi-item reflective and formative measures. Relationship performance and knowledge representation connectivity are formative constructs while the other constructs are reflective. Formative indicators are considered to create a latent construct, do not co-vary, and are not necessarily interchangeable (Chin 1998; Jarvis et al. 2003). Appendix C enumerates response formats and specific items for these multi-item measures.

Relationship Performance. Relationship performance was measured using five formative indicators, relying on a Likert-type scale, developed based on previous work by Selnes and Sallis (2003), Subramani (2004), and Straub et al. (2004a). Measures of relationship performance across the customer and the vendor focus on operating cost,

revenue or total contract value, service quality or service level agreement compliance, order fulfillment or order to delivery cycle time, and new product introduction speed. We also employed other relationship performance measures that rely on a ratio scale to cross-validate relationship performance measures safeguarding against common method bias. The ratio scale measures the performance impact of the relationship by the percentage improvement or decline. Each indicator in the ratio scale captures the concept of the corresponding indicator in a Likert-type scale, but using slightly different wording. Appendix C.2 shows detailed scales used for the customer and vendor survey. Like the approach by Selnes and Sallis (2003), we integrate effectiveness and efficiency elements to measure overall relationship performance.

Contextual Ambidexterity. Alignment and adaptability was measured using three item scales, which were adapted from Gibson et al. (2004). Contextual ambidexterity is measured by multiplying the scores associated with alignment and adaptability, as it is conceptualized as a non-substitutable and interdependent combination of these two properties. Out of nine possible combinations of multiplicative indicators, we chose the first six indicators. In this case, the number of indicators for contextual ambidexterity is not likely to be an issue because the selected indicators show a very high reliability (above 0.98) and thus its number is unlikely to affect the intent of the construct. This is a reflective construct in that the indicators are formed by the construct and they are interchangeable (Jarvis et al. 2003).

Exploratory and Exploitative Knowledge Sharing. Exploratory and exploitative knowledge sharing were measured using four reflective indicators. Exploration and exploitation are considered to be separate constructs with different characteristics (He et

al. 2004). Accordingly, we measure each of them by developing new scales that focus on the three learning myopias (i.e., temporal, spatial, and failure), as identified by Levinthal and March (1993). These myopias represent related, but distinct, aspects of learning and informed the generation of items for each of the two scales. The mapping of the items to the three myopias is presented in Appendix A.2.

Knowledge Representation Connectivity. Knowledge representation connectivity consists of six formative indicators. Drawing on Carlile's (2002) conceptualization of boundary object, we developed digital artifacts at different semiotic levels: syntactic, semantic, and pragmatic. Specifically, the measurement items include the following boundary objects: (1) databases and repositories and standards for data representation at the syntactic level; (2) structured and semi-structured documents (e.g., EDI and XML documents) and unstructured documents (e.g., PDF and multimedia documents) at the semantic level; and (3) process models and business models (e.g., computational models) at the pragmatic level. Informants were asked to report how much they rely on each of these artifacts for this relationship, an approach previously used by Kyriakopoulos and Ruyter (2004b).

Environmental Uncertainty. Environmental uncertainty was assessed using four items adapted from Selnes and Sallis (2003). Informants were asked to evaluate the uncertainty in the environment in which the relationship operates.

Control Variables. We included as controls a number of variables known or expected to affect relationship performance. These are firm size, relationship duration, transaction volume, and incentives for exploration and exploitation. The size of the firms was measured using total number of employees in order to capture any effects of a firm's

size on its relationship performance. Relationship duration was included to assess whether higher relationship performance is related to the length of the relationships (Pillai et al. 2003). To account for the effects of actual transaction activities (Sheth et al. 2003), we included a measure called transaction volume, defined as the percentage of total contract dollars of the relationship. Finally, incentives for exploration and exploitation were included to examine whether incentives influence performance of business partnerships across the supply chain (Ba et al. 2001).

5. MEASUREMENT VALIDATION AND DATA ANALYSIS

The measurement models and structural models were analyzed using partial least squares (PLS) for confirmatory factor analysis (CFA) and hypothesis testing, respectively. The PLS approach was chosen to handle formative constructs (i.e., knowledge representation connectivity and relationship performance) during CFA and hypothesis testing. PLS uses a least square estimation function to obtain parameter estimates and allows us to accommodate both formative and reflective latent constructs. It also places minimal demands on measurement scales, sample size, and distributional assumptions (Chin 1998; Falk et al. 1992; Fornell et al. 1982; Wold 1982). PLS Graph 3.0 was used consistently throughout the analyses.

Before we proceeded to the analysis of measurement models, we applied multiple imputation (MI) (Fichman et al. 2003; Sinharay et al. 2001) to replace missing values with imputations. Since Rubin (1976) developed a basic framework of inference from incomplete data, statistical procedures for missing data have greatly improved and many software products for different techniques are widely available. Information systems researchers have rarely incorporated the analysis of missing data, but this has become quite popular in survey and non-survey contexts (Rubin 1996) in various disciplines such as education (Peugh et al. 2004), medicine (Abraham et al. 2004; Burton et al. 2004), psychology (Roth 1994), and political science (King et al. 2001).

Maximum likelihood estimation and multiple imputation (MI) are known to be superior to ad hoc missing data techniques (listwise and pairwise deletion) with respect to

both bias and efficiency (Enders 2001). One advantage of MI over maximum likelihood estimation is its computational simplicity (Sinharay et al. 2001). The data analyses comprise three steps: 1) creation of $m > 1$ imputed datasets to be analyzed using standard statistical software, 2) analysis of each of the m data sets with standard statistical software, and 3) pooling of the m sets of parameter estimates into a single set of estimates using formulas provided by Rubin. Our customer and vendor datasets have 8.34 and 3.46 percent of missing observations, respectively.

To test for the applicability of MI, we ran a Little's MCAR tests. The insignificant p-values confirmed that our data are missing completely at random (MCAR) ($\chi^2 = 60.74$, $d.f. = 1386$, $p = 1.00$ for the customer dataset; $\chi^2 = 12.79$, $d.f. = 609$, $p = 1.00$ for the vendor dataset). We selected NORM 2.03 (Schafer et al. 1998) for MI. To determine the number of imputations (m), we calculated γ (the rate of missing information for the quantity being estimated) using the formulae by Rubin (1987). The estimated γs for the first four paths (i.e., H1-H4) from the customer dataset are 7.9, 13.2, 7.2, and 9.0, respectively. We chose five imputations to achieve the efficiency of 98 percent given about 10 percent rate of γ. It is known that only 3-10 imputations may be needed in most situations unless the rate of missing information is very high.

To obtain estimates for internal consistency reliability, we relied on the approach suggested by Enders (2003) using an expectation maximization (EM) covariance matrix as input. EM estimates of alpha are known to have less bias and greater efficiency than those from other ad hoc methods. We employed the same input matrix obtained for internal consistency analysis for factor analysis.

Before we proceeded with validating our measurement model with the dataset from customers, we established measurement invariance so that the customer data collected for freight and logistics services could be meaningfully pooled across the groups. For reflective constructs, an omnibus test to examine the null hypothesis of invariant covariance matrices (i.e., $\Sigma^{g1} = \Sigma^{g2}$) across these two services yielded excellent global goodness of fit ($\chi^2 = 307.63$, *d.f.* = 171, root mean square error of approximation = 0.08, normed fit index = 0.97, and comparative fit index = 0.98).

The literature suggests that to establish measurement invariance an omnibus test of the equality of the covariance matrices should be performed first (Bagozzi et al. 1998; Vandenberg et al. 2000). The omnibus test examines the null hypothesis of invariant covariance matrices (i.e., $\Sigma^{g1} = \Sigma^{g2}$), where g1 and g2 indicate the target groups for comparison. The literature indicates that further tests of the other aspects of measurement invariance are not necessary once covariance matrices do not differ across groups (Bagozzi et al. 1998; Vandenberg et al. 2000). Thus we concluded that measurement invariance for reflective indicators was established. As for formative constructs, we sought face validity for measurement invariance by comparing the pattern and magnitude of indicator weights pertaining to a construct. The indicators showed a similar pattern and magnitude of weights across the two groups. Overall, measurement invariance was adequately established across the two services from the customer dataset through which we are allowed to pool the data.

5.1 Measurement Model

Confirmatory factor analysis was used to validate the measures across both the customer and vendor datasets. Reflective constructs were validated using traditional procedures whereas formative constructs (i.e., relationship performance and knowledge representation connectivity) were validated following guidelines by Diamantopoulos and Winklhofer (2001). Table 6 presents correlations among the variables from both datasets.

For reflective constructs, convergent and discriminant validity were assessed first. Composite reliability and average variance extracted for each construct all exceeded a suggested minimum of 0.70 by Agarwal and Karahanna (2000) and 0.5 by Fornell and Larcker (1981), respectively (Table 7). The parameter estimates and their associated *t*-values were all significant. Cronbach's alpha for each of the measures was above the suggested value of 0.70. Specifically, the Cronbach's alphas for alignment and adaptability for the customer data were 0.93 and 0.95, while those for the vendor data were 0.96 and 0.90. These led to a high alpha (0.98) for contextual ambidexterity. Average variance extracted for each construct was higher than the squared correlation between the construct fairs. All measures loaded high (>0.707) on their respective constructs and did not show higher cross-ladings on constructs they were not intended to measure. Cross-loadings were obtained by calculating the correlations between latent variable scores and manifest variable scores[1] (Gefen et al. 2005).

[1] In PLS, the latent variables are weighted composites of the manifest variables. The latent variable scores are calculated by aggregating the product of each indicator and its weight. The calculated scores are then normalized.

Formative constructs require different approaches for measurement validation and establishing convergent validity is not necessary for them (Chin 1998; Diamantopoulos et al. 2001). First, we established content validity by retaining all indicators originally intended to cover the scope of the construct. As for relationship performance, based on a suggestion by Diamantopoulos and Winklhofer (2001), we assessed the quality of individual indicators by correlating them to corresponding variables measured using ratio scales. Each relationship performance indicator in the customer dataset was significantly correlated with its counterpart in a ratio scale, with correlations of 0.37 to 0.53, while those in the vendor dataset are 0.35 to 0.59. Thus all the indicators based on Likert-type scales were retained.

Although the literature provides little guideline on establishing discriminant validity for formative constructs, we examined patterns of item-to-construct correlation and correlations with other constructs. All loadings and cross-loadings for the two formative constructs across the two datasets showed an adequate level of discriminant validity by having high loadings on the constructs they were intended to measure and low cross-loadings on the constructs they were not intended to measure. Although the last indicators (KRC6 and PERF5 in Table 8 and Table 9) exhibited relatively low levels of loading on its intended construct, we considered them acceptable because formative indicators are not expect to covary with each other (Jarvis et al. 2003). The retention of these items is also important from a content validity standpoint. Overall, the measurement instruments exhibited sufficiently strong psychometric properties to support valid testing of the proposed structural models.

Table 6. Correlations

	1	2	3	4	5	6
1. Ambidexterity	-	0.67	0.64	0.69	0.64	0.51
2. Exploitative KS	0.65	-	0.70	0.58	0.62	0.43
3. Exploratory KS	0.64	0.75	-	0.49	0.43	0.31
4. Env. Uncertainty	0.16	0.23	0.27	-	0.71	0.14
5. KRC	0.43	0.49	0.53	0.28	-	0.44
6. Performance	0.67	0.52	0.52	-0.08	0.27	-

Note: The customer dataset is in the lower triangle while the vendor dataset is in the upper triangle. KRC: Knowledge representation connectivity; KS: Knowledge sharing.

Table 7. Reliabilities and Average Variance Extracted for Reflective Constructs

	Customer			**Vendor**		
	Alpha	Composite Reliability	Average Variance Extracted	Alpha	Composite Reliability	Average Variance Extracted
1. Ambidexterity	0.98	0.99	0.94	0.98	0.98	0.90
2. Exploitative KS	0.95	0.97	0.88	0.95	0.96	0.87
3. Exploratory KS	0.96	0.97	0.89	0.92	0.94	0.80
4. Env. Uncertainty	0.80	0.87	0.62	0.88	0.92	0.74

Table 8. Item-to-Construct Correlations from the Customer Dataset (N=238)

Construct	Item	1	2	3	4	5	6
1. Ambidexterity	AMBI1	**0.97**	0.65	0.61	0.20	0.40	0.66
	AMBI2	**0.98**	0.58	0.59	0.22	0.36	0.65
	AMBI3	**0.96**	0.60	0.55	0.23	0.40	0.61
	AMBI4	**0.97**	0.59	0.58	0.17	0.36	0.66
	AMBI5	**0.97**	0.61	0.58	0.22	0.38	0.61
	AMBI6	**0.97**	0.62	0.59	0.27	0.42	0.65
2. Exploitative KS	EIKS1	0.62	**0.94**	0.68	0.25	0.38	0.45
	EIKS2	0.60	**0.94**	0.66	0.30	0.40	0.42
	EIKS3	0.57	**0.95**	0.67	0.31	0.41	0.40
	EIKS4	0.56	**0.93**	0.65	0.33	0.40	0.40
3. Exploratory KS	ERKS1	0.51	0.63	**0.94**	0.25	0.42	0.40
	ERKS2	0.57	0.71	**0.95**	0.25	0.39	0.45
	ERKS3	0.59	0.67	**0.94**	0.31	0.40	0.47
	ERKS4	0.60	0.67	**0.94**	0.28	0.41	0.47
4. Environmental uncertainty	ENVU1	0.28	0.36	0.34	**0.84**	0.26	0.16
	ENVU2	0.09	0.13	0.11	**0.76**	0.13	0.07
	ENVU3	0.05	0.14	0.14	**0.77**	0.13	-0.04
	ENVU4	0.27	0.35	0.31	**0.79**	0.28	0.10
5. Knowledge Representation Connectivity	KRC1	0.33	0.33	0.32	0.18	**0.82**	0.16
	KRC2	0.33	0.42	0.35	0.29	**0.87**	0.19
	KRC3	0.40	0.40	0.43	0.30	**0.86**	0.22
	KRC4	0.35	0.31	0.32	0.21	**0.76**	0.30
	KRC5	0.40	0.40	0.46	0.18	**0.75**	0.35
	KRC6	0.38	0.34	0.34	0.24	**0.50**	0.34
6. Relationship Performance	PERF1	0.60	0.39	0.40	0.02	0.21	**0.80**
	PERF2	0.52	0.44	0.48	0.21	0.31	**0.77**
	PERF3	0.66	0.45	0.51	0.16	0.26	**0.87**
	PERF4	0.59	0.40	0.45	0.11	0.22	**0.83**
	PERF5	0.58	0.47	0.55	0.23	0.34	**0.55**

Table 9. Item-to-Construct Correlations from the Vendor Dataset (N=76)

Construct	Item	1	2	3	4	5	6
1. Ambidexterity	AMBI1	**0.95**	0.66	0.61	0.68	0.62	0.46
	AMBI2	**0.94**	0.65	0.65	0.64	0.55	0.45
	AMBI3	**0.95**	0.57	0.55	0.66	0.66	0.53
	AMBI4	**0.95**	0.69	0.64	0.69	0.62	0.48
	AMBI5	**0.96**	0.59	0.62	0.65	0.57	0.45
	AMBI6	**0.95**	0.64	0.60	0.64	0.63	0.52
2. Exploitative KS	EIKS1	0.65	**0.92**	0.67	0.44	0.57	0.50
	EIKS2	0.70	**0.93**	0.70	0.50	0.55	0.52
	EIKS3	0.56	**0.93**	0.61	0.59	0.56	0.30
	EIKS4	0.57	**0.94**	0.62	0.64	0.63	0.26
3. Exploratory KS	ERKS1	0.63	0.60	**0.86**	0.50	0.40	0.21
	ERKS2	0.47	0.62	**0.91**	0.35	0.45	0.30
	ERKS3	0.61	0.63	**0.87**	0.47	0.22	0.22
	ERKS4	0.59	0.64	**0.94**	0.44	0.46	0.38
4. Environmental uncertainty	ENVU1	0.73	0.63	0.55	**0.89**	0.57	0.14
	ENVU2	0.63	0.61	0.41	**0.86**	0.66	0.18
	ENVU3	0.56	0.46	0.35	**0.88**	0.59	0.11
	ENVU4	0.46	0.29	0.36	**0.80**	0.63	0.05
5. Knowledge Representation Connectivity	KRC1	0.50	0.46	0.31	0.46	**0.83**	0.55
	KRC2	0.67	0.55	0.40	0.65	**0.91**	0.44
	KRC3	0.62	0.47	0.42	0.69	**0.85**	0.25
	KRC4	0.54	0.60	0.36	0.70	**0.84**	0.34
	KRC5	0.59	0.54	0.43	0.71	**0.82**	0.20
	KRC6	0.68	0.43	0.41	0.72	**0.74**	0.24
6. Relationship Performance	PERF1	0.20	0.16	0.25	-0.21	-0.07	**0.59**
	PERF2	0.57	0.65	0.50	0.26	0.45	**0.70**
	PERF3	0.39	0.08	0.02	0.12	0.38	**0.76**
	PERF4	0.20	0.26	0.20	-0.08	0.23	**0.74**
	PERF5	0.16	0.13	0.22	-0.24	-0.05	**0.41**

5.2 Tests of Hypotheses

We performed hypothesis testing using the datasets from the customer and the vendor. A bootstrapping sample of 200 was used to estimate standard errors and to test the statistical significance of structural paths. The control variables were not significant, and thus excluded from further analyses.

To examine common method bias in our data, we first used Harmon's post hoc one factor test (Podasakoff et al. 2003). Principal component factor analysis revealed that the first factor accounted for 21% of the variance, suggesting a single factor did not account for most of the variance. Second, as is documented in prior section, the correlations between the measures for relationship performance and its counterpart based on ratio scale were significant at the 0.01 level. Finally, the path coefficients show different levels of significance across the models. Taken together, we conclude that common method bias is not a serious problem with our data.

We first performed tests to examine the effects of knowledge sharing on relationship performance (H1 and H2) and the effects of contextual ambidexterity on knowledge sharing (H5 and H6). The interaction effects between the two types of knowledge sharing (H3 and H4) were tested using regression-based standard deviation analysis. The effects of the moderators (i.e., knowledge representation connectivity and environmental uncertainty) (H7, H8, H9, and H10) were assessed following the guidelines in the PLS literature (Chin et al. 2003). To test for the full mediation of knowledge sharing on the effects of contextual ambidexterity on performance, the direct effect of contextual

ambidexterity on performance was tested. All the tests except for H3 and H4 were conducted with PLS using the dataset from the customer as well as the vendor.[2]

5.2.1 Tests of the Effects of Knowledge Sharing

The first two hypotheses speculated the expected effect of knowledge sharing on relationship performance (Table 10 and Table 11). The results showed a significant effect of exploratory knowledge sharing on relationship performance with the customer dataset, but this effect was not detected in the vendor dataset. Exploitative knowledge sharing was found to have a positive effect on relationship performance across the two datasets.

The hypotheses H5 and H6 predicted that the greater the contextual ambidexterity, the greater the exploratory knowledge sharing and exploitative knowledge sharing, respectively. Results showed support for the relationships across the two datasets.

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[2] The hypotheses were also tested using two sub-samples of the customer dataset: (1) relationships managed by account managers, and (2) relationships managed by a call center. This test assessed the stability of findings across the sub-samples with varying levels of commitment to the relationship by the vendor. A dedicated account manager on the vendor side managing the customer account represents a higher commitment than when management uses a shared call center. We observe that relationships with account managers last longer and have higher transaction volumes than do call center relationships. Parameters can be appropriately compared between the two groups, as they exhibit measurement invariance, based on global goodness of fit statistics (χ^2 = 205.46, *d.f.* = 171, root mean square error of approximation = 0.041, normed fit index = 0.97, and comparative fit index = 0.99). Hypothesis testing shows that results across the two sub-samples are consistent and these results are also consistent with those found in the entire customer data.

Table 10. Results of PLS Analysis with the Customer Dataset (N=238) [a b]

	Base	Moderation			
Moderator		**KRC**	**KRC**	**Env.**	**Env.**
Exploratory KS → Performance	0.44** (0.08)	0.43** (0.90)	0.45** (0.08)	0.35** (0.09)	0.34** (0.10)
Exploitative KS → Performance	0.21* (0.09)	0.22** (0.89)	0.20** (0.08)	0.22** (0.09)	0.22* (0.10)
Ambidexterity → Exploratory KS	0.60** (0.05)	0.47** (0.66)	0.61** (0.04)	0.60** (0.04)	0.60** (0.05)
Ambidexterity → Exploitative KS	0.62** (0.04)	0.62** (0.43)	0.53** (0.06)	0.61** (0.05)	0.61** (0.04)
KRC → Exploratory KS		0.29** (0.64)			
KRC → Exploitative KS			0.21** (0.07)		
Env. → Performance				0.06 (0.09)	0.07 (0.08)
MODERATION					
KRC × Ambidexterity → Exploratory KS		-0.10 (0.84)			
KRC × Ambidexterity → Exploitative KS			-0.116 (0.10)		
Env. × Exploratory KS → Performance				0.06 (0.09)	
Env. × Exploitative KS → Performance					0.10 (0.13)
R^2 Exploratory KS	0.36	0.45	0.37	0.37	0.37
R^2 Exploitative KS	0.38	0.40	0.38	0.46	0.38
R^2 Performance	0.37	0.38	0.32	0.38	0.33

[a] Unstandardized coefficients are shown, with standard errors in parentheses. One-tailed test.
[b] KRC: knowledge representation connectivity.
* $p < 0.05$
** $p < 0.01$

Table 11. Results of PLS Analysis with the Vendor Dataset (N=76)

	Base	Moderation			
Moderator		**KRC**	**KRC**	**Env.**	**Env.**
Exploratory KS → Performance	0.02 (0.19)	0.02 (0.15)	0.02 (0.16)	0.10 (0.18)	0.12 (0.18)
Exploitative KS → Performance	0.69** (0.15)	0.69** (0.12)	0.69** (0.13)	0.82* (0.25)	0.78* (0.33)
Ambidexterity → Exploratory KS	0.65** (0.06)	0.53** (0.17)	0.65** (0.05)	0.65** (0.05)	0.65** (0.06)
Ambidexterity → Exploitative KS	0.68** (0.06)	0.68** (0.06)	0.38** (0.12)	0.68** (0.07)	0.68** (0.07)
KRC → Exploratory KS		0.05 (0.22)			
KRC → Exploitative KS			0.35* (0.20)		
Env. → Performance				-0.39* (0.21)	-0.36 (0.25)
MODERATION					
KRC × Ambidexterity → Exploratory KS		-0.17 (0.23)			
KRC × Ambidexterity → Exploitative KS			-0.21 (0.25)		
Env. × Exploratory KS → Performance				-0.08 (0.22)	
Env. × Exploitative KS → Performance					-0.06 (0.31)
R^2 Exploratory KS	0.42	0.44	0.42	0.42	0.42
R^2 Exploitative KS	0.46	0.46	0.60	0.46	0.46
R^2 Performance	0.50	0.50	0.50	0.55	0.55

5.2.2 Tests of the Effects of Knowledge Sharing Emphasis

H3 and H4 theorized that relationships with a dual emphasis on exploitative and exploratory knowledge sharing exhibits lower variance-to-mean performance than relationships with exploration-oriented and that exploration-oriented relationships have higher variance-to-mean performance than exploitation-oriented relationships. We excluded the vendor dataset from the testing due to small sample size. To test these hypotheses, the customer dataset was split into four groups that have different knowledge sharing emphasis: dual, exploitation, exploration, and no emphasis. To construct the four groups, we calculated average values for exploratory knowledge sharing and exploitative knowledge sharing. We used the following heuristics to determine group membership for

each of the relationships: (1) "dual" if both exploration and exploitation are greater than or equal to five (out of seven), (2) "exploitation" if exploitation is greater than or equal to five and exploration is less than five, (3) "exploration" if exploration is greater than or equal to five and exploitation is less than five, and (4) "no emphasis" for the remaining relationships.

Following the data analysis approach by He and Wong (2004), we ran a regression model, with the four standard deviation values as the criterion and the four mean relationship performances weighted by group size as the predictor (Adjusted $R^2 = 0.89$) (Table 12). The dual group had the lowest variance-to-mean performance ratio, and its actual standard deviation falls within the 95% confidence interval, implying normal variation. The exploitation-oriented group had the actual standard deviation below the lower bound of the 95% confidence interval, indicating smaller variation relative to its mean value. For the exploration-oriented group, the actual standard deviation was above the upper bound of the 95% confidence interval, intimating larger variation. Overall, the above results provided support for H3 and H4.[3]

We also tested the interaction between exploratory knowledge sharing and exploitative knowledge sharing using the entire customer data, and did not obtain a significant effect on performance. As displayed in Table 12, the dual group shows the highest performance among the four groups, indicating a possibility of the interaction. However, it appears that the interaction is weak and insignificant because of the small sample size in the dual group and the greater portion in the no-emphasis group.

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[3] Raising the cut-off value for group membership makes the four groups severely imbalanced.

Table 12. Results of Regression-based S.D. Analysis [a] [b]

Knowledge Sharing Emphasis	N	Mean	S.D.	S.D./Mean	Lower Bound of 95% CI	Upper Bound of 95% CI
1. Dual	45	5.23	0.89	0.17	0.86	0.89
2. Exploitation	51	4.26	1.03	0.24	1.12	1.13
3. Exploration	16	4.75	1.10	0.23	0.99	1.01
4. No emphasis	126	3.70	1.29	0.35	1.26	1.28

[a] The mean difference between 1 and 2, 1 and 4, 2 and 4, 3 and 4 is significant at $p < 0.05$.
[b] Test of Homogeneity of Variances: Levene statistic = 1.993 ($p = 0.116$); Equal variances assumption is not rejected.

5.2.3 Tests of the Moderating Effects of Knowledge Representation Connectivity and Environmental Uncertainty

To test for the moderation effects in PLS, we mean-centered all the indicators pertaining to independent variables and constructed product indicators from the two sets of indicators following accepted guidelines for examining moderation (Chin et al. 2003). We ran five analyses for each dataset. For each dataset, the base model with the four paths was analyzed first and the four moderation models with the additional set of moderator and product indicator variables were examined next. We added a set of moderator and product indicator variables one at a time to the base model for a moderation test to maximize statistical power and simplify the analysis.

H7-H7a and H8-H8a hypothesized the direct and quasi-moderating effects of knowledge representation connectivity on exploratory knowledge sharing and exploitative knowledge sharing, respectively. Regarding H7 and H8, the customer dataset showed a significant direct effect of knowledge representation connectivity on

exploratory knowledge sharing, but the vendor dataset did not show this direct effect. A significant effect of knowledge representation connectivity on exploitative knowledge sharing was detected in both datasets. H7a and H8a predict that a high level of knowledge representation connectivity strengthens the positive relationship between contextual ambidexterity and knowledge sharing. Results do not support this moderating effect across the datasets.

H9 and H10 investigate the moderating effect of environmental uncertainty on relationship performance. No significant relationship is found for the moderating effects across the datasets, which the results fail to support the hypotheses.

5.2.4 Tests of the Direct Effects of Contextual Ambidexterity

In our theoretical model, we posited that knowledge sharing fully mediates the effect of contextual ambidexterity on relationship performance. In order to test for this mediation, we employed a nested model comparison procedure following an accepted guideline (Chin et al. 2003; Subramani 2004). A partial mediation model was constructed with an additional direct effect from contextual ambidexterity to relationship performance. A f^2 statistic is derived based on R^2 changes between the two models, and is used to compute a pseudo F statistic[4] (see Table 10 and Table 13 for R^2s).

[4] f^2 is calculated using the following formula: (R^2 partial mediation - R^2 full mediation)/(1- R^2 partial mediation). Then pseudo F statistic, f^2 * (n-k-1), is derived. This has 1, (n-k) degree of freedom where n is the sample size and k is the number of constructs in the model.

Results indicated a significant direct effect between contextual ambidexterity and performance in the customer dataset ($f^2 = 0.429$; Pseudo $F = 99.9$) whereas this effect was not exhibited in the vendor dataset (Table 14). To further investigate individual mediated paths, we calculated the products of coefficients and derived *z'* statistics following the MacKinnon et al. (2002)'s approach.[5] This procedure is known to have the most accurate Type I error rates and greatest statistical power. The results show that the customer dataset has significant *z'* scores at $p < 0.05$ along the path of Ambidexterity -> Exploratory Knowledge Sharing -> Performance while the vendor dataset has significance along the path of Ambidexterity -> Exploitative Knowledge Sharing -> Performance. Overall, the effect of contextual ambidexterity on performance is partially mediated by exploratory knowledge sharing in the customer dataset while this effect is fully mediated by exploitative knowledge sharing in the vendor dataset. The direct effect of knowledge representation connectivity on performance was insignificant across the datasets.

[5] $z' = \alpha\beta / \mathrm{SQRT}(\alpha^2\sigma^2_\beta + \beta^2\sigma^2_\alpha)$, where α represents the path coefficient between X (IV) and I (moderator) and β represents the path coefficient between I and Y (DV). *z'* has different critical values than *z* at different significance levels.

Table 13. Results of PLS Analysis for Partial Mediation Test

Relationship		Customer	Vendor
Ambidexterity → Exploitative KS		0.62** (0.04)	0.68** (0.06)
Ambidexterity → Exploratory KS		0.60** (0.05)	0.65** (0.05)
Exploitative KS → Performance		-0.02 (0.08)	0.71* (0.33)
Exploratory KS → Performance		0.22** (0.08)	0.06 (0.30)
DIRECT EFFECT			
Ambidexterity → Performance		0.60** (0.07)	-0.08 (0.53)
R^2	Exploratory KS	0.37	0.42
	Exploitative KS	0.40	0.46
	Performance	0.56	0.50

Table 14. Nested Model Comparison with the Customer Dataset

Models	Path	R^2 in Full Mediation	R^2 in Partial Mediation	f^2 Value	Pseudo F	Result
Full Mediation vs Partial Mediation	Ambidexterity → Performance	0.370	0.559	0.429	99.9	Sig.

5.2.5 Summary of Results

Before we delve into a detailed discussion of our results, we summarize the overall findings (Table 15). On the customer side, explorative and exploitative knowledge sharing have a significant effect on performance and at the same time exploitative knowledge sharing has a relatively weak effect on performance. The effect of exploitative knowledge sharing on performance becomes insignificant when a direct path is added from contextual ambidexterity to performance. There also exists synergy with the duality between exploratory knowledge sharing and exploitative knowledge sharing that enhances performance and reduces variance of performance gains. Management systems are effective in establishing capacity for alignment and adaptation and enable the duality.

On the vendor side, a strong effect is found on the impact of exploitative knowledge sharing on performance, whereas no evidence was found on the impact of explorative knowledge sharing. Exploitative knowledge sharing fully mediates the impact of contextual ambidexterity on performance. Management systems also support both types of knowledge sharing. Knowledge representation connectivity impacts both types of knowledge sharing on the customer side whereas this effect is observed only on exploitative knowledge sharing on the vendor side. Sample size restrictions did not allow for an evaluation of the impact of the duality.

Table 15. Summary of the Predictions and Results

Relationship	Hypothesis	Predicted sign	Customer	Vendor
Exploratory KS → Performance	H1	+	Support	No support
Exploitative KS → Performance	H2	+	Support	Support
Ambidexterity → Exploratory KS	H5	+	Support	Support
Ambidexterity → Exploitative KS	H6	+	Support	Support
KRC → Exploratory KS	H7	+	Support	No support
KRC → Exploitative KS	H8	+	Support	Support
MODERATION				
KRC × Ambidexterity → Exploratory KS	H7a	+	No support	No support
KRC × Ambidexterity → Exploitative KS	H8a	+	No support	No support
Env. × Exploratory KS → Performance	H9	+	No support	No support
Env. × Exploitative KS → Performance	H10	-	No support	No support
KS EMPHASIS				
Dual < Exploration	H3		Support	Not tested:
Exploitation < Exploration	H4		Support	data limitation
MEDIATION				
Ambidexterity → Performance			Sig. (Partial mediation)	N.S. (Full mediation)

6. DISCUSSION

This research is an important application of a rather complicated, but increasingly important concept of exploitation and exploration to long-term interorganizational relationships.

6.1 Theoretical Implications

6.1.1 Dual Knowledge Sharing Emphasis

Tested with customer data, the results suggest that a dual emphasis on explorative and exploitative knowledge sharing enhances relationship performance and reduces its variance. This reduced variance-to-mean performance ratio observed for a dual knowledge sharing emphasis, compared to other patterns of knowledge sharing, suggests that explorative and exploitative knowledge sharing can be reinforcing and synergistic in long-term interorganizational relationships. These results are precisely consistent with the ones by He and Wong (2004), a study conducted at the firm level and in the context of new product development.

We suggest that these synergies may result from dynamic interactions between exploratory and exploitative knowledge, which facilitate better problem solving. First, we speculate that a dual emphasis enlarges the pool of knowledge base and introduces problems for exploration and exploitation in the relationship (Piao 2006). The primary knowledge being added to the pool can be experiential knowledge associated with solving ongoing problems and accomplishing relationship goals, such as what works and what does not work among the partners. Simultaneously, a dual emphasis is likely to

generate new problems or opportunities that should challenge existing practices of the relationship.

Second, once the relationship accumulates knowledge and problems, it may trigger changes to existing exploration and exploitation processes. A primary change can be the revamping of existing exploration or exploitation processes for more effective at-hand problem solving, after recognizing improvement opportunities through the accumulated inputs. This revamping is the natural result of the bounded rationality of a relationship that can never fully understand the problems that challenge the relationship and also cannot prepare satisfactory countermeasures. Next, change can shift an exploitative process to an explorative process or generate an exploitative process from an explorative process (Holmqvist 2004). A key driver of these shifts is dissatisfaction associated with practices of either an exploitative or an explorative end. A combination of these changes helps relationships ward off their tendency to be complacent with current practices, and challenges them to be more innovative and proactive in addressing problems. Thus, relationships should be able to move beyond satisficing outcomes with the support of better problem solving capabilities.

6.1.2 Ambidextrous Design for Long-term Relationship Success

We explored how contextual ambidexterity of the management system applied to a long-term relationship affects relationship performance. We find that contextual ambidexterity fosters both types of knowledge sharing, which, in turn, yield sustained performance benefits. Following Smith and Tushman (2005), we suggest two distinctive processes, enabled by contextual ambidexterity, that facilitate individuals in a relationship to share both types of knowledge simultaneously: differentiating and

integrating. Differentiating processes help individuals clarify distinctions between exploration and exploitation while integrating processes that reconcile conflicts posed by opposing forces and allow for the pursuit of both activities. Interorganizational relationships with institutionalized systems, processes, and beliefs for ambidexterity should provide a context for differentiating and integrating activities.

We observed an interesting difference in the pattern of effects related to contextual ambidexterity across the customer and vendor datasets. For customers, contextual ambidexterity promotes both types of knowledge sharing and they, in turn, affect relationship performance. In contrast, for the vendor, while contextual ambidexterity promotes both types of knowledge sharing, only exploitative knowledge sharing affects relationship performance, specifically revenue and faster order fulfillment. Interestingly, exploratory knowledge sharing does not affect performance for the vendor, possibly because customized, innovative solutions for customers via exploratory knowledge sharing are not always aligned with the structures and processes of the vendor that are optimized for scale economies.

Given the varying patterns of performance emphasis, we speculate that when performance emphasis is either exploitative or explorative, knowledge sharing fully mediates the impact of contextual ambidexterity on performance. On the other hand, when performance emphasis is geared to both exploration and exploitation, the roles of contextual ambidexterity toward performance are much more complicated because they should support reinforcing positive cycles between exploratory and exploitative knowledge sharing. According to Gibson and Birkinshaw (2004), contextual ambidexterity operates at the level of the management system for the relationship as well

as in the specific actions of individuals involved in the relationships. We suggest that contextual ambidexterity at the level of the management system support *additional* activities that make dynamic positive interactions between exploration and exploitation happen.

6.1.3 Enablement by Knowledge Representation Connectivity

Our results suggest that knowledge representation connectivity across syntactic, semantic, and pragmatic boundaries between partners influences the level of knowledge sharing. Knowledge representation connectivity promotes exploratory and exploitative knowledge sharing for customers, whereas it facilitates only exploitative knowledge sharing for the vendor. The results are largely consistent with the literature that identifies important roles of digital objects for knowledge and information sharing. For example, in their research about TradeNet in Singapore, Teo and King (1997) report that TradeNet was used to manage boundary objects, that is, trade declaration documents for controlled and/or dutiable items. The results were faster turnaround times for all types of trade declaration documents, efficient interorganizational information and knowledge processing, and consistent management of boundary objects across different public sector organizations. Also, Scott (2000) observes that IT was used to manipulate and share component designs, CAD drawings and a physical prototype. These boundary objects facilitate knowledge processes among engineers and support learning about assumptions, thus improving model representation.

For the vendor, however, it appears that knowledge representation connectivity is not effective in promoting exploratory knowledge sharing with its customers. Large vendors run standardized systems to fulfill diverse needs from customers. Standardization of

boundary objects across syntactic, semantic, and pragmatic boundaries brings scale economies and maximum efficiency because of reutilization of the same internal resources and routines across customers. When it comes to meeting unique needs from different customers, standardized systems are inflexible and slow to reconfigure to address customized needs for exploratory knowledge sharing. Thus, this standardization lends itself to preventing vendors from exchanging exploratory knowledge.

Different perceptions about what is considered explorative and exploitative between the partners may be another possible reason for the observed insignificant relationship between knowledge representation connectivity and exploratory knowledge sharing. Specifically, we suggest that what is explorative to customers may be exploitative to vendors. A large vendor, who is an industry leader, maintains an innovation stream to address diverse customer needs. An innovation stream comprises extant products and services under continuous refinement, and emerging products and services under innovations (Smith et al. 2005). It is conceivable that a vendor periodically introduces a new product or service to the market to meet changing customer needs. When a new product or service is introduced to a few selected lead users (or customers) (von Hippel 1986), a vendor is likely to consider it as innovation. After a couple of successful applications, the product or service is no longer new or explorative in its portfolio of innovation streams. Customers are basically in the position of followers in such a vendor-customer relationship and any product or service that is not known to customers, although it now becomes part of vendor's standardized package or solution for customers, is likely to be new and explorative in the eyes of customers.

Given that interactions for the moderator knowledge representation connectivity was not observed, we provide the following two reasons. First, the non-significant results may come from lack of power that leads to a failure to detect the phenomenon that actually exists. Probably the most important determinant of statistical power is effect size (Baroudi et al. 1989). It is likely that the effects were not observed because double multiplications toward a scale for interaction terms caused us to lose unique characteristics of each variable involved. Contextual ambidexterity was calculated by multiplying items between alignment and adaptability and interaction terms were obtained after multiplying items between contextual ambidexterity and knowledge representation connectivity. Another cause can be imperfect reliability among the indicators of knowledge representation connectivity that can impose an upper bound on the effect size that can be detected (Baroudi et al. 1989). Knowledge representation connectivity is a formative construct and its indicators do not need to have a high reliability. We speculate that formative construct may be less effective in detecting the effects than reflective construct.

Second, knowledge representation connectivity provides the relationship with substance, tools, and action guidelines for exploratory and exploitative knowledge sharing. However, it is conceivable that represented knowledge is not properly assimilated and therefore, does not make full use of the potentials of information technology so that its use can lead to synergistic effects across boundaries. By providing systematic mechanisms for acquisition, storage, and dissemination of knowledge across the boundaries, boundary objects and associated information technologies are effective platforms for knowledge sharing. To bring maximum benefits to the parties involved,

these platforms must be fully assimilated into the ongoing interorganizational work processes beyond adoption and deployment stages (Purvis et al. 2001). This assimilation of IT platforms in a sophisticated manner is challenging because they should address diverse concerns of the stakeholders surrounding the relationships. Thus, it may be important to have requisite institutional, social, and political structures to support full assimilation into interorganizational practices. Purvis, Sambamurthy, and Zmud (2001) proposed management championship as an effective means of mobilizing commitment toward assimilation of information technologies.

6.1.4 Differences in Learning Emphasis between Vendors and Customers

While customers realize performance gains from explorative and exploitative knowledge sharing, the vendor realizes performance gains from exploitative knowledge sharing. This suggests that vendors, especially large ones with significant centrality and power in their industry, may be focused on scale economies and revenues. The scale economies can result from resource transferability and activity complementarity (Anderson et al. 1994). "Resource transferability" regards the extent to which knowledge or solutions are transportable. The focal firm may possess knowledge or solutions from other relations that are required to address the needs of a relation. The focal firm can also utilize the same resources to meet similar needs from other customers. "Activity complementarity" refers to the possibility of integrating activities from different relations with each other. This complementarity can be volume-based or quality-oriented. For example, increased volume in certain relations can generate scale economies in other relations, which will lower the overall transaction costs. Such carrying capacity of a focal

firm may be viewed as a public-good element from the standpoint of customers (Aldrich et al. 1994), and bring about beneficial results for parties in alliances (Silverman et al. 2002).

Such capacity allows the focal firm to generalize its relationships with its customers (Anderson et al. 1994), which may cause negative results to some relationships. Based on our results, customers are concerned with innovation, combining both exploration and exploitation, resulting from their long-term partnerships, given their dependence on the vendor. However, the focal firm may generalize (or do not identify) different concerns of customers and address them within its capacity to maximize scale economies by capitalizing on existing knowledge or solutions.

On the vendor side, such activities are viewed as exploitation and this approach does not necessarily address diverse concerns about exploration from its customers. Anderson et al. (1994) identify this detrimental effect to individual customers for participating in the alliances as "deleterious effects on network identity." They explain how resource transferability and activity complementarity can turn into "resource particularity" and "activity irreconcilability" when it comes to addressing unique needs from different customers in the network.

6.1.5 Influence of Relationship Context in Valuing Shared Knowledge

Following the literature that external environments have the potential to affect the value of knowledge sharing, we introduced environmental uncertainty as a moderator variable into our model. The results across the customer and vendor dataset show that

environmental uncertainty does not influence the way knowledge sharing affects relationship performance. Overall, the literature provides mixed support for moderation effects of environments. In the context of new product development, Moorman and Miner (1997) report that while technological and market turbulence do not moderate the impact of memory level, they do moderate the effect of memory dispersion. In interorganizational relationships, Johnson, Sohi, and Grewal (2004) found no overall moderation effects - except in the industries characterized by moderate levels of turbulence - of environmental turbulence on the use of the environmental knowledge stores (knowledge about external environment).

Based on the lack of observation of interactions, we suggest that the relationship context may be more important than the actual environment in determining the value of knowledge sharing. Relationship context is largely determined by service level agreements made between a vendor and its customers. The agreement aims to create a common understanding about services, priorities, and responsibilities, and is used to facilitate the access to and transfer of knowledge (Powell et al. 1996). Specifically, a knowledge sharing agreement determines the degree of knowledge exposure to its partner and its opportunities to access external knowledge. This in turn influences the profitability of the relationship (Wuyts et al. 2004) and ways that gains are appropriated by each party. Thus it may be that the value of shared knowledge is less influenced by environmental uncertainty than it is affected by the relationship context determined by a knowledge sharing agreement.

6.1.6 Focal Firm's Central Role for Innovation

In the current environment, firms face the dual pressures of globalization (global location of production/distribution facilities) and time-based competition (Bhatnagar et al. 2000). These pressures can be alleviated by enhancing manufacturing performance, but even that has limitations. Ideally, firms can address such pressures by combining manufacturing and logistics functions seamlessly. As these pressures intensify, the logistics function has been gradually recognized to be a crucial source of value creation. This growing importance can be easily calculated in the portion of logistics costs as a percentage of the sales dollar (4.4 percent for pharmaceuticals, 14 percent for manufacturing companies, and 26 percent for merchandising companies) (Bowersox et al. 1996).

Logistics alliances to address these pressures while reaping mutual benefits from collaboration are a natural strategic direction between manufacturing firms and logistics providers. The strong drivers of such alliances are to bring cost benefits to both sides of the alliance, and to synergistically combine each firm's competence to enhance the competitive position of both firms (Bhatnagar et al. 2000).

Logistics alliances are characterized by logistics service providers and their customers such as manufacturing firms and wholesale and retail traders. Logistics service providers offer integrated logistics solutions including freight services and logistics services, which deal with warehousing, inventory recording, re-labeling and packaging, and the handling of customer returns (Bhatnagar et al. 2000). This industry is dominated by global logistics service providers (GLSPs) such as Federal Express, United Parcel Service, and DHL. These and other GLSPs have accumulated tremendous capabilities

that enhance customer services, which are facilitated by substantial investments in technology. Manufacturing firms are focused on excelling in manufacturing and they consider logistics a non-essential component. Logistics activities, however, are gradually becoming their strategic component that enables global presence and creates solutions for time-based competition. Through logistics alliances, manufacturing firms can focus on their core business activities while leaving their secondary, but important, logistics activities to GLSPs.

In logistics alliances, GLSPs are key players with the prominence and power to bring innovation after integrating the dispersed resources and capabilities of their customers to create value. In such an alliance network, effective value creation largely depends on active, purposeful efforts of a focal firm (i.e., a GLSP) (Dhanaraj et al. 2006). An important task of a focal firm, who maintains various innovation streams to address diverse customer needs, is to facilitate knowledge sharing within its alliance network. As discussed earlier, the focal firm can access knowledge or solutions arising from other customers within its network and thus can learn from the experiences of others. The focal firm can also transfer knowledge or solutions to other customers and integrate activities of different customers with each other. Thus the focal firm plays a crucial role in the creation and sharing of knowledge among the network partners.

In order to generate mutual benefits via the creation and sharing of knowledge, the focal firm should ensure the absorption of knowledge from its partners (Dhanaraj et al. 2006). As our results show, in long-term relationships exploratory and exploitative knowledge are equally important. Customers in such relationships are interested in introducing innovations while running existing processes efficiently so that they can

better address the diverse needs of the market. The demands for innovation can be expressed in the form of suggestions, feedback, and complaints about existing practices to the focal firm. In our research context, the range of these demands can vary slightly depending on freight or logistics services relationships, but the relationships share the same characteristics of equal emphasis on both types of knowledge sharing.[6] It is the responsibility of the focal firm to absorb diverse demands and shared knowledge from customers based on its existing capabilities, and in turn to forward learned knowledge and solutions to its customers so that the innovation network can benefit the focal firm as well as customers in its network.

6.2 Practical Implications

This research has important practical implications. In today's competitive situations, balancing exploration and exploitation is necessary and essential for sustained value creation in long-term interorganizational relationships. Managers therefore should recognize enlightening potentials that emanate from the juxtaposition of opposing forces for long-term performance of relationships. This research suggests that seemingly contradictory forces can turn into synergies if they are dual and if this duality persists with the requisite establishment of appropriate interorganizational design mechanisms and IT. Hence, managers in the relationships should not be obsessed with the traditional

[6] In our customer dataset, the relationships that are focused on logistics services have higher levels of knowledge sharing (exploitation = 4.71 out of 7 scale, exploration = 4.02) than those associated with freight services (exploitation = 4.25; exploration = 3.94). Freight services, however, also maintain high levels of knowledge sharing.

either-or logic, but rather should strive to prepare strategies which will usher in a host of new opportunities out of synergies from both learning activities. A strategy to manage the paradox and maintain duality is contained not in plans, but in the composition and maintenance of the environment that fosters individuals' ambidextrous behaviors. In constructing such environments, firms should rely on a holistic approach in which structures, processes, and information systems are orchestrated to confront and transcend the tension.

Regarding roles of IT for interorganizational learning, it is tempting to associate IT with exploitative initiatives only: enhancing transaction efficiencies by streamlining business processes. This is because many IT applications strengthen process management practices that promote incremental innovation and tend to dampen radical innovation. For example, workflow management systems (WfMS) are designed to automate entire work processes. Successful WfMS deployment results in significant benefits such as process cycle time reductions, improved accuracy, and greater worker satisfaction. It may be argued that such results are short-term benefits that are less relevant to long-term oriented exploration.

Our findings with the customer dataset, however, showed that IT is instrumental in facilitating exploratory as well as exploitative learning. These findings are consistent with the observation of the potentiality of IT platform for exploration and exploitation by providing digital options in the form of digitized organizational work processes and knowledge systems (Sambamurthy et al. 2003). Also, IT can facilitate exploratory learning by enabling scanning, problem formulation, and sense-making within and across firms. Thus, the important issue is not whether IT promotes exploration and/or

exploitation, but rather what facilitating mechanisms allow organizations to realize the full potential of IT for innovation. Therefore, managers should realize the breadth of learning that can be enabled by IT and should strive to make use of the full potential of IT beyond automating existing business processes.

The long-term performance of logistics alliances hinges on sharing both types of knowledge simultaneously. To facilitate knowledge sharing, the relationships should establish an environment in which customers' knowledge is easily shared with the focal firm, this knowledge is properly appropriated at the focal firm, and the focal firm delivers timely solutions or enhanced knowledge to customers based on the initially shared knowledge from customers. In the presence of dedicated account managers, account managers as boundary spanners are responsible for facilitating knowledge sharing and knowledge application across the partners. In the absence of account managers, the focal firm should establish additional mechanisms for knowledge sharing to complement limited capabilities of a call center. When the knowledge to be shared is complicated, as is to be expected more in logistics services relationships than in freight services relationships, boundary spanners across the partners should play greater roles in facilitating knowledge sharing. Also, the focal firm should have systematic mechanisms to properly absorb the shared knowledge from customers, to identify their unique as well as common needs, and to prepare the proper solutions after integrating its diverse resources and activities. When the focal firm delivers customized solutions to customers, the focal firm should have much more sophisticated mechanisms for knowledge sharing and knowledge application than when it delivers standardized solutions.

6.3 Limitations and Future Research

This research has certain limitations. We collected the data using a single informant on each supply chain relationship, which is the approach consistent with most prior research on interorganizational relationships (e.g., Subramani (2004); Straub et al. (2004b)). Thus the data quality largely depends on the knowledge of the participants. We relied on the focal firm in the context of logistics alliances. This approach provides a unique advantage of warding off confounds by controlling for industry effects, but at the same time limits the ability to generalize the results. Finally, we provide only a snapshot of the results for the phenomenon that are ongoing in nature.

Future research can extend the findings of this research. An important first avenue for research would be to identify the gap or difference in learning emphasis between the parties in alliances and to examine its performance implications. In our research, the focal firm is mostly interested in exploitation, whereas the customer is concerned with exploration as well as exploitation. It would be interesting to see whether this gap is reduced as the relationships evolve to become more or less equal partnerships, and whether a narrower gap contributes to heightened relationship performance by *both* parties involved.

Second, given the different learning emphases, the relationships may employ opportunistic learning strategies at the expense of the partners. If firms behave opportunistically, the relationships may be terminated prematurely, incurring enormous expenses to both parties. Thus, another direction of future research would be to examine the proper incentive mechanisms across the relationships that will reconcile disparate learning interests and intensify the level of collaboration across the border.

Third, many IS researchers have investigated performance implications of process technologies, such as enterprise resource planning (ERP). A neglected issue is the impact of process technologies on process improvement. Future research should investigate the impact of process technologies on process improvement and in turn the influence of process improvement on innovation and organizational performance.

Finally, vendors are likely to be under constant pressure to provide comprehensive IT solutions that could facilitate both exploratory and exploitative knowledge sharing across boundaries. One probable approach of vendors would be to derive the greatest common denominator of diverse customer needs and implement standardized systems to satisfy the common needs. Although this is one of the best approaches for vendors, it would satisfy some customers while isolating others. This is the inherent dilemma when large vendors seek technically efficient solutions for heterogeneous customers. Future research should investigate the nature and characteristics of the tension surrounding standardized technical solutions among stakeholders in IS and ways to resolve the tension. A relevant issue to examine would be whether service-oriented architecture can support innovation in interorganizational relationships with its loosely coupled and interoperable services.

7. CONCLUSION

Consistent interests in organizational learning as a viable means of organizational prosperity have led researchers to emphasize the crucial roles of balancing exploration and exploitation for sustained value creation. While conceptually interesting, few empirical studies have investigated this idea. In this research, we extended this notion to the context of interorganizational relationships and empirically tested its tenets. Furthermore, we extended the basic notion of duality to include its antecedents, which include interorganizational design and IT. While the basic tenets of our arguments were supported, the results painted a much more complicated picture as to which types of innovation are important for the parties involved. Specifically, the customers emphasized exploration and exploitation simultaneously while the vendor focused on exploitation. This implies the relationships do not operate uniformly over which innovations are important for value creation when each firm in the relationship has different goals to achieve from the collaboration. These different emphases are correspondingly reflected in their use of IT for innovation. These results imply that relationship managers who are involved must be vigilant about the possibility of different goals for innovation across the board and look for ways to overcome this discrepancy in order to achieve heightened mutual performance.

APPENDIX A. POLICY CAPTURING SCENARIOS

A.1 Role-Playing Scenarios

A.2 Measurement Instruments for Knowledge Sharing

(The newly-created instruments for Knowledge Sharing are shown here to describe its detailed characteristics.)

A.1 Role-Playing Scenarios

Your Role and Task at Hand

You assumed the role of relationship manager of Mega Logistics (ML), a company in the logistics industry, five years ago. You lead a team responsible for providing logistics solutions to and managing the relationship with Savannah Pharm (SP). As a relationship manager, you are concerned with developing effective short- and long-term strategies for this relationship.

ML's management has asked you to evaluate the performance and management of the SP relationship. Your experience suggests that evaluation of relationship performance must encompass long- and short-term aspects and that relationship performance is impacted by the management systems, exchange of knowledge between companies, and the information technology (IT) platform used to facilitate this exchange. Based on your team's investigation of SP's relationship, the following report has just been delivered to you.

Mega Logistics Background

Founded in 1950, the company is a medium-sized logistics specialist located in New York. From the 1950s to 1970s, it delivered packages for U.S. pharmaceutical firms to wholesale, distributors and retailers. Through mergers and acquisitions in the 1980s and 1990s, the company expanded its capabilities to offer cutting-edge solutions that leverage IT for logistics. For the last five years, ML has established relationship manager roles and teams that work with customers to formulate and implement short- and long-term strategies to improve their logistics performance.

Distribution Logistics Industry for Pharmaceuticals

Distribution logistics is concerned with the stocking and flow of products and information from the manufacturer through a logistics channel to the customer. The competitive imperative is to fulfill orders placed by customers in good quality and time, without holding high levels of inventory to accomplish this. Partnerships between pharmaceutical manufacturers and logistics companies have been growing rapidly. Some firms, such as ML, have developed such partnerships with pharmaceutical customers to improve the efficiency and quality of existing processes and also explore logistics innovations for new markets and products. These partnerships are being enabled by advances in IT that enable companies to exchange real-time information on operational activities and to collaborate on opportunities for logistics innovation (e.g., simulations of processes).

The Customer - Savannah Pharm

For the last five years, Savannah Pharm, a mid-sized U.S. pharmaceutical company, has partnered with ML for its logistics services. ML moves branded drugs from SP's warehousing facilities to a network of 200 wholesalers, distributors, and retailers. Expectations for performance are specified in service level agreements that are negotiated between the two companies. While significant improvement in the logistics of branded drugs has been achieved, there are still performance improvement opportunities to be realized.

SP is preparing to launch a new line of generic drugs as the market for its branded drugs matures. For the last year, SP has been working with ML to develop a new logistics model from that used earlier for the distribution of these generic drugs. Market research indicates that a well-developed new logistics process will yield enormous revenue gains and control inventory costs.

Efficiency-Oriented Management Systems

Alignment (H)

The management systems for this relationship work coherently to support overall relationship objectives and excel in achieving the efficiency objectives of the relationship. Efficient utilization of resources is promoted by business plans that clearly map responsibilities. Top management has developed and communicated consistent objectives that enable people to minimize working at cross-purposes and use resources productively.

Alignment (L)

The management systems for this relationship do not work coherently to support overall relationship objectives and are very poor in achieving the efficiency objectives of the relationship. Efficient utilization of resources is not promoted by business plans that map responsibilities. Since top management has not developed and communicated consistent objectives, people end up working at cross-purposes and do not use resources productively.

Adaptive Management Systems

Adaptability (H)

The management systems for this relationship facilitate business initiatives that challenge outmoded traditions and practices, and promptly respond to the changing business environment. The management systems are highly responsive to market shifts through reconfiguration of activities and evolve rapidly when business priorities shift.

Adaptability (L)

The management systems for this relationship lack the ambition and overarching vision needed to challenge outmoded traditions and practices, and do not promptly respond to the changing business environment. The management systems are highly unresponsive to market shifts and do not reconfigure activities. They do not evolve even when business priorities shift.

Sharing of Knowledge about Existing Logistics Processes

High

There are still performance improvement opportunities to be realized in the logistics of branded drugs. ML and SP have been extensively discussing why the compliance with pre-defined performance goals is not achieved, and why shipments are being lost or delayed. After intense joint sessions, it was discovered that strategies, technologies, and processes for day-to-day operations need to be improved. Since then, the two companies have been extensively exchanging ideas about low-risk, short-term, easy to achieve improvement opportunities focused on a few selected parts of the logistics process. They have also been exchanging lots of ideas about improvements to existing measurement approaches so as to obtain an accurate assessment of short-term performance compliance. The two companies have also discussed at length approaches to low-risk fine-tuning of existing information systems.

Low

There are still performance improvement opportunities to be realized in the logistics of branded drugs. However, ML and SP have not been discussing why the compliance with pre-defined performance goals is not achieved, and why shipments are being lost or delayed. Although the companies have discovered that the strategies, technologies, and processes for day-to-day operations need to be improved, they are reluctant to discuss for their resolution. No idea has been exchanged between the companies about low-risk, short-term, easy to achieve improvement opportunities, a few selected parts of logistics process that can be refined, and how measures can be improved to obtain an accurate assessment of performance compliance. The two companies have had no discussions on approaches to low-risk fine-tuning of existing information systems.

Sharing of Knowledge about New Logistics Opportunities

High

The new line of generic drugs requires a radically different logistics model from that used for branded drugs. Exchange of ideas concerning the development of strategies and plans for the new logistics model has been extensive. ML has also been comprehensively exchanging novel ideas with SP about experimentation for new business opportunities, highly risky innovative opportunities, and long-term success of the relationship. The two companies are also extensively evaluating how to re-structure and re-design IT and standards for the real-time exchange of information across the end-to-end logistics process - between production, warehousing, and logistics.

Low

The new line of generic drugs requires a radically different logistics model from that used for branded drugs. Exchange of ideas concerning the development of strategies and plans for the new logistics model has been absent. ML has not been exchanging novel ideas with SP about experimentation for new business opportunities, highly risky innovative opportunities, and long-term success of the relationship. Furthermore, there have been no

discussions between SP and ML on how to re-structure and re-design IT and standards for the real-time exchange of information across the end-to-end logistics process - between production, warehousing, and logistics.

ML's management has further asked you to quantify the performance of SP's relationship. You have decided to meet the management's concern using the following survey that reflects the above report delivered to you.

A.2 Measurement Instruments for Knowledge Sharing

Please indicate the extent to which each of the following items reflects the knowledge exchange practices in this relationship. Knowledge includes information, skills, ideas, and know-how. (Seven-point Likert-type scale: Strongly Disagree / Strongly Agree)

A.2.1 Exploitation

Components	**Characteristics**	**Measurement Item**
Core feature	・Improvement and refinement	Our companies exchange knowledge related to refining the existing logistics process.*
Temporal myopia	・Short-term over long-term survival ・Compliance and commitment to strategies and value creation approaches for the short-term success of the relationship	Our companies exchange knowledge related to improving compliance with the short-term goals for the relationship.
		Our companies exchange knowledge to refine existing measures for short-term performance compliance.
Failure myopia	・Risk-averse over risk-taking	Our companies exchange knowledge for low-risk, short-term improvements.
Spatial myopia	・Components over whole in terms of process	Our companies exchange knowledge related to refining a few selected parts of the logistics process.
	・Components over whole in terms of information technology	Our companies exchange knowledge related to low-risk fine-tuning of existing information systems.*

A.2.2 Exploration

Components	Characteristics	Measurement Item
Core feature	• Experimentation	Our companies exchange knowledge related to experimentation for new business opportunities.
Temporal myopia	• Long-term over short-term survival • Originality in strategy and value creation approaches essential to long-term success of the relationship	Our companies exchange knowledge related to strategies for long-term success.
		Our companies exchange "out of the box" ideas for the long-term success of the relationship.
Failure myopia	• Risk-taking over risk-averse • Confidence becomes excessive if the experiential record of success is a poor predictor of future successes • Persistent failure leads to a tendency to overestimate the risks of actions, and persistent success leads to a tendency to underestimate the risks of actions • Higher failure rates for exploration may constrain sharing of innovative ideas	Our companies exchange knowledge about highly risky innovation opportunities for the relationship.*
Spatial myopia	• Whole over components in terms of process	Our companies exchange knowledge related to novel approaches for end-to-end logistics process integration.
	• Information technology architectures and integration technologies going beyond components to focus on system-wide coordination	Our companies exchange knowledge related to restructuring information systems for end-to-end coordination of the logistics process.*

Note: * Items are dropped during measurement purification process.

APPENDIX B. LETTERS FOR SURVEY

B.1 Pre-survey Letter to Customers

B.2 First Survey Request to Customers

B.3 Second Survey Request to Customers

B.4 Survey Request to Vendor

B.1 Preletter to Customers

Dear [customer name]:

A few days from now you will be receiving a brief survey at this email address. The survey is part of a study on customer relationship management being conducted by SupplyChainCo in collaboration with the Center for Process Innovation at Georgia State University.

The survey concerns how customer relationships between your company and SupplyChainCo for freight and logistics should be managed to improve existing ways of creating value and discovering new ones. The study will generate fine-tuned knowledge for your company and SupplyChainCo to achieve their short- and long-term objectives.

We will greatly appreciate it if you can take a few minutes to complete the survey. By doing so, you will ensure that the results are based on the best information possible. Of course, all information provided is strictly confidential. We are writing to you in advance of sending the survey as many people like to know ahead of time that they will be contacted.

If you have any questions, feel free to contact [contact info].

Thank you for your time and consideration.

Sincerely,

[sender info]

B.2 First Survey Request to Customers

Title: Request by SupplyChainCo & Georgia State Univ. for Survey Participation

Dear [customer name],

As a valued customer of SupplyChainCo, we are seeking your help in completing a survey on customer relationship management. As mentioned in earlier email, this survey is part of a study on customer relationship management that is being conducted in collaboration with the Center for Process Innovation at Georgia State University.

This survey is concerned with the best ways of creating short- and long-term value for customers. The results will be used to develop specific guidelines on how management systems, including information systems, can help achieve sustained value creation.

Your answers are completely confidential and will be used to create summaries where no individual's answers can be identified. Participation in this survey is voluntary. However, you can greatly help us by taking a few minutes of your valuable time to share your experience with SupplyChainCo.

You can respond by clicking on the following link:

[SurveyLink]

As a token of our appreciation, we will share an executive report with you within three months of completing the study.

Should you have any questions, you can reach [contact info].

Thank you very much for helping with this important study.

Sincerely,

[sender info]

B.3 Second Survey Request to Customers

Title: Reminder - Request for survey participation by SupplyChainCo and Georgia State Univ.

Dear [customer name],

About three weeks ago we sent you a survey on customer relationship management, being conducted by SupplyChainCo in collaboration with researchers at Georgia State University. This is a gentle reminder requesting your participation so that we can effectively identify best practices for sustained value between customers and SupplyChainCo. Many customers have shared their experiences and thoughts - we hope that you will be able to take 10-15 minutes from your valuable time to do so as well.

Your answers are completely confidential and will be combined with others to generate summary findings, which we will share with all participants in the form of an executive report.

You can respond by clicking on the following link:

[SurveyLink]

Should you have any questions or concerns, feel free to contact [contact info].

Thank you for your help and cooperation.

Sincerely,

[sender info]

B.4 Survey Request to Vendor

Title: Request for Participation Customer Relationship Management Study

Dear [account manager name],

We are conducting a survey about customer relationship practices to discover the best ways to create short- and long-term value for SupplyChainCo and its customers. We are collaborating with the Research Center for Process Innovation at Georgia State University, a neutral academic third-party who will maintain confidentiality of responses and report only aggregate results.

Data are being collected from both customers and SupplyChainCo account managers to identify similarities and differences in views about practices and performance of the relationship. The results will provide us insights on ways to enhance systems and procedures for improved value creation.

Customer name, Company name, Account number has completed the survey. As their account manager, we are requesting you to complete a survey from a SupplyChainCo perspective. The customer has focused their responses on **[Freight or Logistics]**, so please focus all your answers on the relationship for this service.

To proceed to the survey, please click on the following link:

[SurveyLink]

You will greatly help this study by spending 10-15 minutes of your valuable time to complete this survey. As a token of our appreciation, we will share an executive report with you shortly after completion of the study.

You may receive another such request if other customers that you manage have participated in this study.

Should you have any questions, you can reach [contact info].

Thank you very much for helping with this important study.

Sincerely,

[sender info]

APPENDIX C. SURVEY INSTRUMENTS

C.1 SupplyChainCo Relationship Management Survey

(The survey instruments for customers and the vendor are integrated for ease of comparison. The vendor name is suppressed to provide anonymity.)

C.2 Relationship Performance Scales

C.1 SupplyChainCo Relationship Management Survey

This study investigates how relationships should be managed to create maximum mutual benefit for SupplyChainCo and its partners. The survey should take 15 minutes of your time. All information provided will be kept confidential. In appreciation for your time, you will receive a report about best practices related to management, information technology, knowledge exchange, and performance consequences. Your cooperation in making this research a success is critical and much appreciated.

[*For Customer*]: Please provide responses that best describe the relationship of your business unit with SupplyChainCo for [freight services/logistics]. Logistics refer to the flow and storage of goods, funds, and related information from point-of-origin to point-of-consumption.

[*For SupplyChainCo*]: Please provide responses that best describe the relationship of SupplyChainCo with this customer for [freight services/logistics]. Logistics refer to the flow and storage of goods, funds, and related information from point-of-origin to point-of-consumption.

SECTION 1 - Relationship Performance [7]

Relationship Performance*
How would you rate this relationship in overall terms over the last two years?
1. For the most part, this relationship is very successful for us.
2. Overall, this relationship is very satisfactory for us.

Relationship Performance [*For Vendor and Customer*]
(Seven-point Likert-type scale: Strongly Disagree / Strongly Agree)
By working with this partner, [the vendor/our business unit] has received the following benefits over the past 2 years:
1. Reduced operational cost for [vendor / business unit] operations. (PERF1)
2. Increased revenue. (PERF2)
3. Improved service quality. (PERF3)
4. Faster order fulfillment. (PERF4)
5. Improvement in the launch of new products. (PERF5)

Relationship Performance [*ONLY for Vendor*]
(Ratio scale: % Improved, % Declined)

[7] Unless otherwise specified, we used the following scale: (Seven-point Likert-type scale: Strongly Disagree / Disagree / Slightly Disagree / Neutral / Slightly Agree / Agree / Strongly Agree).

To what extent has the following been impacted for the vendor over the past 2 years as a result of this relationship?

1. Total cost of vendor operations.
2. Change in [freight services / logistics] total contract value.
3. Service level agreement compliance.
4. Order to delivery cycle time.
5. New product introduction speed into this customer's organization.

Relationship Performance [*ONLY for Customers*]
(Ratio scale: % Improved, % Declined)
To what extent has the following been impacted for your business unit over the past 2 years as a result of the relationship with the vendor?

1. Operating cost.
2. Inventory cost.
3. Revenue.
4. Service level agreement compliance.
5. Order to delivery cycle time.
6. New product introduction speed into markets.

SECTION 2 - The Management Systems

In this section, please evaluate the management systems supporting the relationship. The management systems refer to the systems and processes that influence the behaviors of personnel. For example, service level agreements, incentives, planning and review meetings, and methods for contract renegotiation make up the management system for the relationship.

Contextual Ambidexterity: Alignment

Please indicate the extent to which the management systems of the relationship support efficiency-oriented goals.

1. The management systems in this relationship work coherently to support the overall objectives of this relationship.
2. The management systems in this relationship facilitate the efficient utilization of resources.
3. The management systems in this relationship cause us to use resources on productive activities.*****
4. People in this relationship end up working at cross-purposes because our management systems give them conflicting objectives.*****
5. The management systems in this relationship support achievement of efficiency-related objectives of this relationship.

Contextual Ambidexterity: Adaptibility

Please indicate the extent to which the management systems of the relationship support adaptation to meet changing requirements of the business environment.

1. The management systems in this relationship encourage people to challenge outmoded traditions/practices/sacred cows.*
2. The management systems in this relationship are flexible enough to allow us to respond quickly to changes in our markets.
3. The management systems in this relationship evolve rapidly in response to shifts in our business priorities.
4. The management systems in this relationship facilitate reconfiguration of activities to respond to changes in the external environment.

SECTION 3 - Communication Practices for Knowledge Exchange

In this section, please evaluate the extent to which communication occurs in this relationship to exchange knowledge (e.g., skills, ideas, and know-how). This communication can span meetings, telephone conversations, e-mail, database access, document transmissions, and sharing of process models and business models.

Exploitative Knowledge Sharing

Please indicate the extent to which the following practices are used to improve existing [freight services / logistics] processes for the relationship.

1. Our companies exchange knowledge related to refining the existing [freight services / logistics] process.*
2. Our companies exchange knowledge related to improving compliance with short-term goals. (EIKS1)
3. Our companies exchange knowledge to refine existing measures for assessing short-term performance goals. (EIKS2)
4. Our companies exchange knowledge for low-risk, short-term improvements. (EIKS3)
5. Our companies exchange knowledge related to refining a few selected parts of the [freight services / logistics] process. (EIKS4)
6. Our companies exchange knowledge related to low-risk fine-tuning of existing information systems.*

Exploratory Knowledge Sharing

Please indicate the extent to which the following practices are used for [freight services / logistics] innovations relative to this relationship.

1. Our companies exchange knowledge related to experimentation (e.g., pilot tests) for new business opportunities. (ERKS1)
2. Our companies exchange knowledge related to strategies for long-term success. (ERKS2)
3. Our companies exchange novel ideas for the long-term success of the relationship. (ERKS3)
4. Our companies exchange knowledge about innovation opportunities that involve significant risk and uncertainty.*
5. Our companies exchange knowledge related to new approaches for end-to-end [freight services / logistics] process integration. (ERKS4)

6. Our companies exchange knowledge related to restructuring information systems for end-to-end coordination of the [freight services / logistics] process.*

SECTION 4 - Information Systems (IS)

Knowledge Representation Connectivity

For this relationship, our company relied on the following:

1. *Databases* and repositories with consistent data (e.g., databases for consistent tracking of shipment and inventory data). (KRC1)
2. *Standards* for data representation (e.g., common formats for file layout, record and field length). (KRC2)
3. Structured and semi-structured *documents* with shared meaning across the relationship (e.g., EDI and XML documents with agreed definitions for shipment and inventory). (KRC3)
4. Unstructured *documents* with shared meaning across the relationship (e.g., PDF and multimedia documents with agreed definitions for activities and performance). (KRC4)
5. *Process models* (e.g., specification of roles, activities, measures, and process interfaces). (KRC5)
6. *Business models* (e.g., computational models about risk and return). (KRC6)

SECTION 5 - Environment

Environmental Uncertainty

Please evaluate the uncertainty in the environment in which this [freight-services / logistics] relationship operates.

1. Customer needs and preferences related to [freight-services / logistics] change rapidly. (ENVU1)
2. The competitors in our industry frequently make aggressive moves related to [freight-services / logistics] to capture market share. (ENVU2)
3. Crises related to [freight-services / logistics] have caused some of our competitors to shut down or radically change the way they operate. (ENVU3)
4. It is very difficult to forecast where [freight-services / logistics] technology will be in the next 2-3 years in our industry.*
5. In recent years, a large number of new product ideas related to [freight-services / logistics] have been made possible through technological breakthroughs. (ENVU4)

Decision Complexity*

Please evaluate the nature of decision-making in this relationship.

1. The decisions made in the relationship frequently involve interactions with the partner.
2. Our decisions in this relationship are relatively unaffected by decisions of the partner.
3. Our decisions in this relationship are dependent on information shared by the partner.
4. We collaborate with the partner for decisions pertaining to the relationship.

SECTION 6 - Background

1. What is your position? (Senior Executive/Mid Level Manager/Analyst)
2. How many overall years of professional business experience do you have in the workforce? Years _____
3. For how long have you been involved in the management of the relationship between [the vendor and this customer / your business unit and the vendor]?
   Years _____
4. Our goal for this relationship is to:
   a. refine and improve existing solutions used for our [freight services / logistics] activities (Seven-point Likert-type scale: Strongly Disagree / Strongly Agree)
   b. develop new solutions for our [freight services / logistics] activities (Seven-point Likert-type scale: Strongly Disagree / Strongly Agree)
5. What is the total number of employees in your business unit? _____ [*ONLY for Customers*]
   (1 - 99 / 100 - 249 / 250 - 499 / 500 - 999 / 1,000 - 2999 / 3000 - 5990 / 6000 - 9,999 / 10,000 or more)
6. How long has this relationship been in existence? Years _____ [*ONLY for Vendor*]
7. What percentage of your time is allocated to:
   a. day-to-day operations.
   b. investigation of innovative [freight services / logistics] solutions.
8. What percentage of your total [freight services / logistics] contract dollar volume is sourced from the vendor? _____ [*ONLY for Customers*]
9. What percentage of your total [freight services / logistics] budget is allocated to [freight-process/logistics process] R&D? _____ [*ONLY for Customers*]
10. What innovative [freight services / logistics] solutions is your business unit seeking? [*ONLY for Customers*]
11. From your perspective, what would be an ideal relationship with the vendor? [*ONLY for Customers*]

Note: * Items or constructs are dropped because of measurement concerns.

C.2 Relationship Performance Scales

For Vendor:

Likert-type scale	Ratio scale
1. Reduced operational cost for [vendor / business unit] operations. 2. Increased revenue. 3. Improved service quality. 4. Faster order fulfillment. 5. Improvement in the launch of new products.	1. Total cost of vendor operations. 2. Change in [freight services / logistics] total contract value. 3. Service level agreement compliance. 4. Order to delivery cycle time. 5. New product introduction speed into this customer's organization.

For Customer:

Likert-type scale	Ratio scale
1. Reduced operational cost for [vendor / business unit] operations. 2. Increased revenue. 3. Improved service quality. 4. Faster order fulfillment. 5. Improvement in the launch of new products.	1. Operating cost. 2. Inventory cost. 3. Revenue. 4. Service level agreement compliance. 5. Order to delivery cycle time. 6. New product introduction speed into markets.

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EDUCATION

Doctor of Philosophy	Georgia State University, 2006 Major area: Computer Information Systems
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RESEARCH INTERESTS

- Interorganizational relationships
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- Organizational learning and knowledge management
- Software development

TEACHING INTERESTS

- Programming languages
- Systems analysis and design
- Database management systems
- Computer security
- Knowledge management
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- Quantitative method

WORK EXPERIENCE

A. Academic

- 2001 - 2006, Instructor and graduate research assistant, Department of Computer Information Systems, Georgia State University

B. Business

- 2000 - 2001, Software Engineer, Verizon Communications, White Plains, NY
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