ABSTRACT

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Abstract:

This dissertation investigates the use of information exchange in industrial supply chain relationships. Specific information exchange characteristics are analyzed to determine their contribution to firm performance from the perspective of both the technology champion firm and the trading partner firm. Longitudinal analyses are conducted using data gathered from an electronically mediated industrial exchange network. This unique dataset, which includes information exchange data for thirty-nine technology champion firms and their electronically integrated trading partners across a two-year observation period, provides distinct insights into the application and outcomes related to information exchange in contemporary supply chains. The analysis of this large volume of information exchange transactions identifies best practices in the use of information exchange and their impact on firm performance.

SUPPLY CHAIN STRATEGY AND THE BENEFITS OF INFORMATION EXCHANGE

By

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Dedication

To my wife Sue and my sons, Josh and Nick, whose love and support allowed me to keep my eye on the prize and finish this race.

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Chapter 1: Introduction

1.1 Information Exchange in the Supply Chain

The cost-effective, timely, and accurate exchange of information allows today's supply chains to efficiently deliver innovative solutions. Using the latest technology and supply chain strategies, a consumer in the U.S. can order a laptop computer online direct from the manufacturer. The manufacturer is able to custom build the laptop in Malaysia, coordinate the manufacture of the docking station and monitor stand in China, and have the entire order delivered within six days. In order to efficiently deliver this level of service to customers, multiple manufacturers and logistics providers are coordinated into a single virtual business entity.

A key component of any business's success is its ability to balance the costs and benefits of maintaining relationships with their trading partners. Exchanging information with trading partners is a central element in maintaining relationships. The cost of exchanging information includes the technology infrastructure as well as the gathering and formatting of the data. Sharing the wrong information with the wrong trading chain partner may cost the firm its competitive advantage and allow opportunistic actions by customers, suppliers, and competitors. Sharing the right information at the right time with the right trading chain partners can reduce costs and enhance competitive advantage.

Not all supply chain relationships are equal and each requires unique amounts and types of information. Some business-to-business (B2B) exchanges are defined by closely integrated seamless relationships while others are defined by arms-length market relationships. Simple arms-length market relationships may require only the most basic exchange of cost and quantity information. These loose relationships exist when the buyer requests a specific catalog item, quantity, and delivery date. The supplier responds with the cost, item availability, and payment terms. The exchange is coordinated based on a minimal exchange of information to support the order cycle process. Other more tightly integrated relationships may require ongoing real-time exchanges of production plans, point-of-sale demand data, inventory quantities, and shipping schedules. The exchange of additional information allows for the coordination of production and logistic functions above and beyond the order cycle process. Information exchange that is tailored to meet the needs of the relationship benefits performance by getting the right information to the right trading partner at the right time in order to support interfirm decision making.

Supply chain relationships differ in their characteristics as well as their outcomes. The degree of trust, level of commitment, use of shared knowledge, access to systems and information, and use of shared goals vary among B2B supply chain relationships. Most firms do not build close supply chain relationships just for the sake of integration; they develop close relationships for the positive outcomes that are created. For example, when interviewing the regional sales manager for a large cable manufacturer, he cited specific outcomes from building close relationships with customers. Both the firm and its customers experienced benefits from the relationship. Its customers experienced positive supply chain performance outcomes, including reductions in average inventory, increased inventory availability, access to R&D resources, greater flexibility to adjust order quantities inside manufacturing lead time, and access to enhanced emergency response services. The cable manufacturer benefited from increased flexibility in managing its order backlog, improved accuracy of forward production planning, better cost control through level production loading, and the avoidance of switching costs. This manufacturer noted that these benefits become possible when information flows seamlessly between organizations within the context of close supply chain relationships.

Firms can identify the unique types and volumes of information exchange necessary to build and maintain each relationship. At a basic relational level, procurement and sales personnel from two distinct firms coordinate quantity, price, payment terms, and delivery information to support the exchange of products. At the other end of the relational spectrum, marketing and engineering personnel in distinct firms may exchange complex information to coordinate joint R&D efforts for the development of next generation products and services. In both situations, firms make decisions about the types of information that are exchanged in order to efficiently and effectively coordinate their resources.

Direct modes of information exchange such as face-to-face, teleconferencing, and telephone contacts allow for immediate feedback among the parties. Due to the interactive nature of these modes, the exchange parties need to be available at the same time in order to coordinate the information exchange. Scheduling constraints in supply chains that extend across time zones serve to further decrease flexibility and increase the cost of using these traditional modes of information exchange. When immediate feedback and interaction are not required, information can be exchanged through email, electronic data interchange (EDI), voice mail, or web-based applications. These indirect information exchange modes support the efficient transfer of large amounts of information without both exchange parties being available at the same time. Email text and attachments are sent by one firm and stored by the recipient firm until the information is needed. Although lacking in immediate feedback mechanisms, these technology-based information exchange modes have the advantage of conveying large amounts of information in a form that can be accurately stored and shared with others (Subramani 2004; Vickery et al. 2004). Firms may choose the mode of information exchange that best suits their situation.

1.2 Strategic Use of Supply Chain Relationships

Increased competition makes the management of supply chain relationships a strategic issue for firms. Researchers note that supply chains exist whether they are managed or not (Mentzer et al. 2001). However, the successful management of supply chains can be a source of competitive advantage for firms (Dyer and Ouchi 1993; Houlihan 1985). Supply chain management (SCM) is described as the strategic management of individual firms as a single entity in order to bring a product or service to the market (Vickery et al. 2003). The American Production and Inventory Control Society (APICS) provides a process oriented definition of SCM:

> *The design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally.* (APICS, 2006)

Collectively, these two definitions of SCM create a holistic view of SCM recognizing that the individual firms in a supply chain are distinct entities that share a common interest in operating as a single vertically integrated system.

The linking of internal firm processes to external customers and suppliers is recognized as a key element in the management of supply chains. Through an empirical test of five integration strategies, researchers found a correlation between firms with higher performance and their increased use of integration (Frohlich and Westbrook 2001). Their survey-based study asked firms to rate the degree of integration with both their customers and suppliers. The highest performing strategy was found to be linking closely with both customers and suppliers. In their study, information exchange was a key indicator of integrated relationships. Integrated relationships are characterized by the sharing of production plans and the use of shared information systems.

Information technology (IT) facilitates the exchange of information in the supply chain. Inherent in the traditional model of a supply chain are the flow of products toward the end customer and the flow of information toward the raw materials suppliers. In its most basic form, information only flows upstream from the end customer toward the raw materials supplier. This type of information flow often consists of only basic order information that informs the supplier to ship a specific item to the requesting customer.

Today's advanced IT capabilities support the fast and efficient flow of large volumes of diverse information both upstream and downstream in the supply chain. To enhance the coordination of the supply chain among customers and suppliers, firms often share inventory information, quality reports, demand forecasts, production schedules, and marketing research with both customers and suppliers. These bi-directional flows of information go against the traditional model of the supply chain information flow but are recognized in both academic literature and business practice (Spekman et al. 1998).

Technological advances enhance the ability of firms to gather, store, and transfer information. The ability of a firm to use IT is recognized as a source of firm performance advantage (Bharadwaj 2000; Santhanam and Hartono 2003; Zhu and Kraemer 2002). Beyond the mere presence of IT, researchers find that technology facilitates the exchange of information between trading partners (Spekman et al. 1998). Recognizing the role of IT in facilitating supply chain integration, IT has been modeled as an antecedent of supply chain integration (Vickery et al. 2003).

IT connections and integration strategies create linkages among firms in the supply chain, but linkages alone do not integrate firms. Moving information seamlessly between a company and its trading partners facilitates the strategic integration that coordinates firms in the supply chain (Mukhopadhyay et al. 1995). Specifically, information is most useful in a supply chain context when it is timely, accurate, and relevant to decision making (Bakos and Brynjolfsson 1993; Whipple et al. 2002). The exchange of information across these interfirm linkages integrates the firms and allows them to perform as a single virtual organization.

1.3 Contribution of the Dissertation

This dissertation addresses existing gaps in the literature by examining the effect of information exchange on supply chain performance. Specifically, this dissertation examines IT enabled information exchange between firms in the supply chain.

This dissertation makes four unique and significant contributions related to the use of information exchange in supply chains:

- This dissertation extends the theoretical link between information exchange and supply chain participant performance. Prior research recognizes the role of information exchange in supply chains but has been limited in its measurement. These analyses use a unique archival dataset from an electronically-mediated industrial exchange network to develop measures of actual information exchanges in B2B relationships.

- This dissertation expands the growing body of literature on supply chain management by maintaining a perspective that performance is associated with the effective management of interfirm relationships. The exchange of information with trading partners is specifically advanced as a key element of interfirm relationships that has not been fully developed in the literature.

- This dissertation identifies dimensions of information exchange that contribute to the relational performance of firms in the supply chain through the use of dyadic observations of B2B interactions. Using event history analysis tools and performance measures from strategic management literature, the association between information exchange characteristics and relationship termination is developed. U-shaped relationships are identified where the effects of information exchange characteristics are negative at lower volume levels and positive at higher volumes.

- This dissertation identifies dimensions of information exchange that contribute to the operational performance of firms in the supply chain. A panel dataset of thirty-nine technology champion firms is used for hypotheses testing. Findings suggest that close trading partner relationships may be detrimental to performance.

The remainder of this dissertation is structured as follows: Chapter 2 discusses and applies relevant theory, Chapter 3 presents the methodology and data, Chapter 4 identifies and tests hypotheses related to relationship termination, Chapter 5 identifies and tests hypotheses related to firm operational performance, and Chapter 6 offers conclusions and directions for future research.

Chapter 2: Theory and Review of Extant Literature

2.1 Introduction

This chapter uses transaction cost theory (TCT) to build a theoretical approach to understanding the effects of information exchange within electronically-mediated supply chain relationships. This unique investigation into the role of information exchange in supply chain relationships has both academic and practical application.

TCT is an appropriate theoretical lens for supply chain research because it can be used to evaluate the effectiveness of buyer-supplier relationships (Grover and Malhotra 2003). TCT identifies specific characteristics of interfirm exchanges and assumptions about firm behavior to guide a firm's choice of relationship governance structure. Simply put, TCT recognizes that there are attributes of business exchanges which may require firms to manage the relationship more carefully in order to avoid unfavorable outcomes.

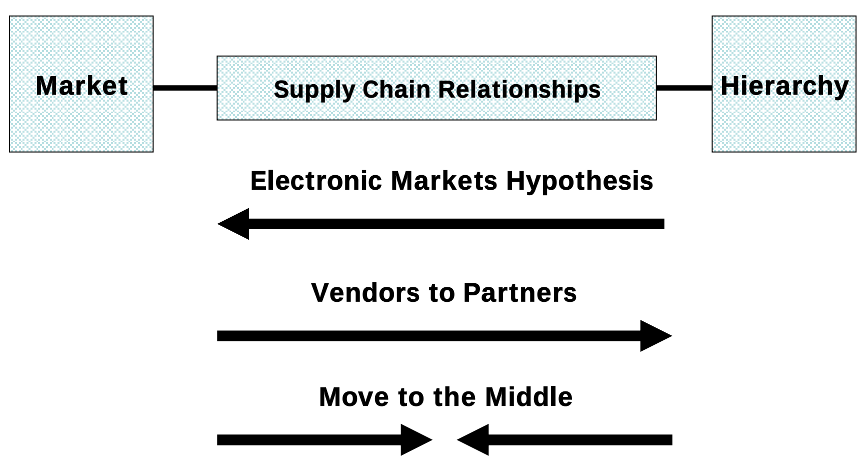
The chapter proceeds with an overview of the key elements of TCT that apply to this dissertation and an introduction of extant literature to form a framework for research into the use of information exchange in supply chain relationships.

2.2 Transaction Cost Theory in a Supply Chain Context

TCT proposes that firms decide strategically whether to make their inputs or purchase their inputs from the market (Williamson 1975; Williamson 1985). Transaction costs are incurred when firms procure inputs from outside sources. These transaction costs include searching for a source of supply, negotiating, coordinating the exchange, and monitoring the transaction.

The decision of whether to make or buy inputs was initially described as a dichotomous choice of either market or hierarchy (Williamson 1975). This dichotomy was later expanded as a continuum of governance structures, recognizing that market characteristics and hierarchy characteristics could be blended in forming a continuum of business relationships (Webster 1992). The space between the dichotomous choices of market and hierarchy was described as “hybrid” by Williamson (1985) and is depicted as supply chain relationships in Figure 2.1. The hybrid space recognizes that firms can organize their external transactions using non-price mechanisms which create unique governance structures ranging from closely connected relationships to arms-length market transactions (Williamson 1985).

Figure 2.1 Information Technology and the TCT Framework



The continuum between pure markets and internal hierarchies has been used to describe the nature of supply chain relationships. At the far left extreme of the supply chain relationship continuum, the relationship is typically an arms-length or "market-like" relationship between a supplier and its customer. These exchanges differ from a pure market exchange because the exchange is not discrete but occurs repeatedly between the same two participants such that a relationship exists through an expectation of future exchanges. This type of relationship may exist when commodities are repeatedly exchanged and the relationship is primarily governed by price mechanisms. At the other extreme -- corresponding to the right-hand "hierarchy" end of the continuum -- are close relationships where suppliers tightly integrate with their customers. The earlier example of a cable manufacturer that works closely with select customers to coordinate production and demand would be an example of a relationship on the hierarchy end of the supply chain relationship continuum. At the far right of the continuum are the processes that have been moved into the firm's hierarchy and are no longer external supply chain relationships but instead are vertically integrated internal processes. Within the continuum in the middle are supply chain relationships characterized by varying levels of integration.

TCT posits that the decision of how to manage relationships is determined by factors of the exchange transaction which include three dimensions and two assumptions. The three dimensions of exchange identified by TCT are: the frequency of exchange, the amount of uncertainty, and the degree of asset specificity (Waldman and Jensen 1998). The two assumptions are bounded rationality and opportunism.

The frequency of exchange recognizes that how often firms transact to acquire a given input affects the overall cost of transacting. If an input is only required occasionally, the firm may choose to use the market. If, however, the input is needed often, the cost of repeatedly renegotiating procurement from the market will increase aggregate transaction costs. While discrete purchases may be transacted through the market, when multiple transactions are required to supply an input, firms will tend to move toward internalizing the transaction to reduce their overall cost (Williamson 1985). In practice, firms move away from discrete pure market transactions and create blanket purchase orders that govern the exchange for a specific period of time.

Uncertainty in exchange relationships is often a result of coordination problems between exchange partners. When one party is unsure of the plans and intentions of its exchange partner, slow or inappropriate decisions can increase costs. In practice, this can occur when items that are ordered are not delivered when expected. The customer is unsure why the ordered items were not delivered and may subsequently decide to order the items from another source rather than waiting for the initial order to be delivered.

Asset specificity addresses the ease with which firms can reallocate assets to other relationships. If assets are dedicated to supporting a specific relationship and cannot be reallocated to a new relationship, these transaction-specific investments can be the source of lock-in or hold-up (Shapiro and Varian 1998). When a specialized asset is allocated in a buyer-seller relationship, the party holding the specialized asset has few options to protect the loss of that asset beyond maintaining the existing relationship. Difficult and lengthy contract negotiations, cost concessions, and ongoing monitoring requirements needed to protect the specialized asset create additional transaction costs. In practice, suppliers may co-locate their facilities inside of the customer's warehouse in order to provide unique services. In such a case, the supplier incurs costs to set-up the operation which may not be transferred to another relationship if the customer decides to change suppliers. An additional aspect of asset specificity occurs when a supplier develops a unique input for a customer specified need. If the customer decides that the input is no longer needed, then the supplier may have no use for the production capability, existing inventory, or unallocated R&D expenditures.

TCT posits that underlying these three dimensions are two assumptions. TCT assumes that transacting parties are limited in their ability to collect and understand all issues related to the exchange (bounded rationality) and that if given the opportunity firms will behave selfishly in ways that are detrimental to the other party (opportunism).

Firms incur costs to overcome bounded rationality and avoid opportunistic behavior. The writing of extensive contracts and carefully monitoring the exchange are two ways that firms protect themselves. However, as any of the three dimensions of exchange (frequency, uncertainty, and asset specificity) increase, there is a greater opportunity for firms to act opportunistically thus requiring additional transaction costs in order to reduce the risk. Increased transaction costs require a firm to choose a governance structure closer to a hierarchy structure in order to minimize the risks of the outside firm not performing as expected. When transaction costs become higher than the cost of internally producing the good, firms will seek the most efficient governance mechanism available, which may include internalizing the transaction and not exchanging with outside firms (Williamson 1975).

Opportunism is a unique phenomenon in business since it affects interfirm transactions by both its occurrence and its risk of occurrence. Opportunistic behavior occurs through misleading reports, misrepresented work time, quality shirking, and similar actions reported regularly in the newspaper. These specific actions create costs that affect firm financial and operational performance. But opportunistic behaviors do not need to occur in order to create costs for firms. The mere risk of opportunism can cause firms to incur prevention costs (Wathne and Heide 2000).

Even when the risk of opportunism is high, firms may choose to not act opportunistically. Literature has proposed that long-term orientation (Ganesan 1994), relational contracts (Ring and Ven de Ven 1992), pledges and idiosyncratic investments (Anderson and Weitz 1992), and explicit written contracts (Ring and Ven de Ven 1992) can discourage opportunism. But whether opportunism occurs or only the potential exists, costs are incurred.

The availability of information affects these transaction costs within the TCT framework. Price alone effectively and efficiently coordinates pure markets. In an environment of perfect information, the price mechanism coordinates exchange with minimal transaction cost. Unfortunately, buyers and sellers do not possess perfect information and the resulting information asymmetry increases the cost of transacting through the market. On the surface, one might predict that these increased costs would prompt firms to avoid transacting with the market. In the long run, firms could develop internal capabilities to provide many of the inputs required for production. But in reality, firms always rely on some level of outside input either because of technical expertise, availability of resources, or economies of scale (Pfeffer and Salancik 1978). So in the short run, and often in the long run, firms rely on outside sources for inputs. If firms can decrease the comparative transaction costs of using the market, it is economically justifiable to continue using market sources for inputs.

2.2.1 The Effect of Information Technology on the TCT Framework

The application of information technology (IT) in supply chain relationships has changed the balance between markets and hierarchies by decreasing the cost of transacting outside the firm's boundaries (Clemons and Row 1992; Malone et al. 1987). The reduction of external coordination costs has two distinct outcomes. First, in situations where transaction costs would have forced firms to internalize exchange, the use of IT decreases the cost of exchange and allows the transaction to occur with external suppliers. Research into the use of IT in the supply chain has shown that firms are using IT to reduce their internalized transactions and form more relationships with external firms (Brynjolfsson et al. 1994; Hitt 1999).

Improvements in IT have greatly reduced external coordination costs, thereby decreasing transaction costs. As shown in Figure 2.1, the incorporation of IT into the markets and hierarchies discussion has added richness to the TCT framework by helping predict movement along the continuum. The electronic markets hypothesis (EMH) recognizes that the use of IT to facilitate interfirm information exchange lowers the costs of transacting outside of the boundaries of the firm. Using IT is expected to decrease the cost of search, document processing, and monitoring. Lower transaction costs are hypothesized to encourage firms to interact with the market rather than internalize transactions (Malone et al. 1987). The EMH was followed by the vendors-to-partners thesis which recognizes that IT can be used to form close interfirm relationships where hierarchy-type benefits could be achieved in external (supply chain) relationships. Firms are predicted to move away from discrete market transactions to form closer relationships which enhance quality, responsiveness, and innovation (Bakos and Brynjolfsson 1993; Saeed et al. 2005; Subramani 2004).

These two perspectives are important because although they both support that firms will increase their use of outside suppliers, they differ in how firms will use outside suppliers. EMH predicts an increased use of the market. Conversely, the vendors-to-partners thesis predicts the use of close relationships that are similar to a vertically integrated hierarchy but still outside of the firm boundaries.

Balancing these perspectives, the “move to the middle” was proposed (Clemons et al. 1993; Gurbaxani and Whang 1991). The “move to the middle” posits that the use of IT will create a balance between market and hierarchy benefits in supply chain relationships. This balanced perspective is important since it recognizes the trade-offs that must be managed when integrating IT in supply chain relationships. How IT changes the way interfirm business is conducted depends on the resources and needs of the participating firms. Some will take advantage of more accessible markets (EMH) while other firms will use IT to seek improved performance through collaboration (vendors to partners). The move to the middle is an important realization that firms will use a mix of IT strategies to manage their portfolio of trading partner relationships. While the literature is unclear where relationships will fall along the continuum, the use of IT to facilitate low cost interfirm transactions is consistent.

While the use of IT can be seen as a benefit to enable firms to efficiently interact with external trading partners, the literature is inconsistent on the appropriate closeness of supply chain relationships and how much information should be shared. So many studies have shown the benefits of close trading partner relationships that one might assume that closer is better. However, additional research has suggested that the trading partner pool be treated as a portfolio. Through a portfolio perspective, close relationship are developed with specific trading partners while other trading partners are kept at arms-length (Lambert et al. 1996a; Lambert et al. 1996b; McCutcheon and Stuart 2000).

2.2.2 The Effect of Information Exchange on the TCT Framework

Information exchange is central to the coordination of firms in a supply chain context and is instrumental in both markets and hierarchies under the TCT framework. From a markets perspective, the exchange of information is central to the efficient operation of the price mechanism. Neoclassical economics assumes that full information is available to all market participants at no cost. This full availability of information to all exchange participants in the market allows the price mechanism to efficiently clear the market. Full information is rarely available to all parties in the exchange, but the parties can choose to exchange information. When information is exchanged within supply chain relationships, firms can decrease the uncertainty and lower the cost of monitoring the relationship.

TCT recognizes that information is not equally and fully available to all exchange participants. TCT acknowledges information asymmetry and presupposes that information is available to the exchange parties – for a price. The cost of searching, gathering, and using information increases the cost of coordinating transactions with the market (Williamson 1975; Williamson 1985).

Within the TCT framework, information exchange also can decrease transaction costs. Information decreases transaction costs through its effect on uncertainty, coordination, and monitoring. First, the availability of information decreases uncertainty by providing additional knowledge to trading partners. The relationship becomes less uncertain when demand information, firm goals and intentions, and production plans are known and shared between exchange partners. When information is shared in advance, there is less uncertainty about the intentions of the trading partner if problems do occur (Rozenzweig et al. 2003). Second, information is used to efficiently coordinate transactions. When suppliers know demand forecasts, marketing plans, and point-of-sale information, order quantities are expected and properly planned to minimize both overstocking and stockouts (Metters 1997). Information technology has been used extensively to facilitate the low-cost exchange of information to support the order processing cycle. Finally, information is used to facilitate monitoring mechanisms to protect against opportunistic behavior when specialized assets are at risk. When production schedules, plant capacities, inventory positions, and shipment schedules are known across the supply chain, firms have greater visibility into the operations of their trading partners (Rozenzweig et al. 2003). The regular exchange of this information allows for the monitoring of key interfirm processes critical to governance mechanisms under TCT.

The downside of close trading partner relationships includes the cost of development and the risk of opportunism. Since the cost of developing a relationship cannot be recovered or applied to a new relationship, these costs represent a specific asset that is lost if the relationship fails to develop. The costs of developing close trading partner relationships depend on many factors including the level of integration and governance structure (Lambert et al. 1996a). Complex interactions and specific capital investments may require extensive formal agreements to coordinate their resources. Such investments in time and capital are then protected under the terms of the contract. If the anticipated benefits do not materialize, then firms have incurred unnecessary costs. Similarly, the transparency that develops when information is shared between firms may allow trading partners to act opportunistically by withholding some benefits of the relationship (Shapiro and Varian 1998). In summary, this literature stream suggests that rather than pursuing close relationships with trading partners, it is more effective to develop close relationships with the right trading partners (Lambert et al. 1996a; Lambert et al. 2004).

Research has linked the exchange of information between firms to the strategic issue of supply chain integration. Using survey data from a sample of global manufacturers, Frohlich and Westbrook (2001) tested the relationship between supply chain integration strategy and performance. The study included both the direction of integration (customer facing or supplier facing) as well as the degree of integration (no integration to extensive integration). The study found that the greatest performance improvements were made by firms with the highest levels of integration with customers and suppliers. Information is central to the integration of firms in the supply chain. Frohlich and Westbrook (2001) used four information exchange measurements to capture the integrative activities of firms. The integrative activities used by firms to link with their external supply chain participants are each based on information exchange. This research clarifies the bi-directional role of strategic information exchange in supply chain relationships.

Marketing channels literature also supports the vital role of information exchange in supply chain relationships. Using organization theory and communications theory, researchers posit that the communications strategy is a moderator between channel conditions and channel outcomes (Mohr and Nevin 1990). This vital role of communications between supply chain participants is empirically tested and validated through the operationalization of communication as frequency, direction, modality, and content (Rinehart et al. 2004; Vickery et al. 2004).

2.3 Review of Empirical Literature

2.3.1 Use of Information in Supply Chains

Inventory can be a significant cost driver in supply chains. Having too much inventory causes firms to accrue unnecessary carrying costs. Having too little inventory causes firms to accrue unnecessary stockout costs. Researchers suggest that information can be a substitute for inventory (Daugherty and Pittman 1995). In practice, when forecasts, inventory positions, and actual demand are shared with upstream suppliers inventory needs can be planned such that goods are produced when needed rather than held in inventory in case they are needed.

Specific research into demand distortion has shown that information can reduce the buildup of unneeded inventory. Demand distortion, also known as the bullwhip effect, is a phenomenon whereby upstream supply chain participants experience volatility in demand greater than the actual consumer demand volatility (Lee et al. 1997; Metters 1997). When the bullwhip effect occurs, small fluctuations in consumer demand create larger fluctuations in replenishment orders upstream in the supply chain. These distortions of demand cause upstream participants to build-up inventory far beyond what is required to satisfy consumer demand. Research into the causes of the bullwhip effect suggests that exchanging additional information including inventory status, order coordination, and point-of-sale data could reduce the bullwhip effect (Chen et al. 2000; Lee et al. 1997).

Researchers using the beer game simulation, have found that information sharing does dampens the bullwhip effect (Croson and Donohue 2006). In their study, the sharing of information allowed upstream suppliers to anticipate downstream inventory needs. In a similar beer game simulation, it was found that the sharing of point-of-sale (POS) information upstream in the supply chain dampened the bullwhip effect but the results varied depending on the nature of the demand pattern (Steckel et al. 2004). They found that when demand is volatile (S-shaped demand pattern) then the sharing of POS information becomes a distraction to the more immediate issue of responding to orders.

The exchange of information between supply chain participants has benefits beyond dampening the bullwhip effect. Through the modeling of a two-tier supply chain with one supplier and multiple retailers, it has been shown that sharing demand information can reduce inventory across the supply chain by as much as 12% (Cachon and Fisher 2000). Sharing demand information is shown to improve manufacturer forecasting accuracy and decrease safety stock (Raghunathan and Yeh 2001). This research examines the role of information exchange in improving supply chain performance.

2.3.2 Information Exchange to Support Specific Supply Chain Initiatives

The exchange of information in the supply chain is found to support strategic initiatives. These initiatives are thought to be strategic in nature because they allow firms to create unique competitive advantages by implementing interfirm processes. Vendor managed inventory (VMI) is an interfirm process whereby the supplier is authorized to manage inventories of his downstream customers. Since the VMI supplier has the freedom to make re-supply decisions for the retailers, inventories and transportation can be synchronized for both echelons (Cetinkaya and Lee 2000). Similarly, the continuous replenishment process (CRP) allows the upstream supplier to control restocking at retail locations. Studying a single manufacturer engaged in CRP with its retailers, it was found that stockouts were reduced and inventory turnover was increased (Lee et al. 1999). Programs like CRP allow inventory to be coordinated across multiple echelons of the supply chain. Variability in demand is absorbed upstream by keeping safety stock to satisfy demand when forecasts understate the actual demand. Researchers have shown that the sharing of demand information improves the upstream manufacturer's forecast accuracy and allows for decreases in safety stock (Raghunathan and Yeh 2001).

The use of just-in-time (JIT) processes has shown benefits for supply chain participants by allowing them to minimize the buildup of inventory throughout the supply chain. Using a survey methodology, researchers found that use of JIT is directly related to savings in logistics costs for buyers (Dong et al. 2001). Similarly combining the use of

EDI with a JIT environment has been shown to reduce shipment errors (Srinivasan et al. 1994).

Each of these interfirm processes are designed to improve supply chain performance by coordinating resources across the supply chain. Successful coordination is dependent on the exchange of accurate and timely information (Angulo et al. 2004).

2.3.3 Using Interorganizational Systems to Exchange Information

Interorganizational systems (IOS) have been identified for their boundary spanning role in integrating firms in the supply chain (Zaheer and Venkatraman 1994). These systems take many forms and use various technologies including: EDI, email, electronic exchanges, Web-based applications, and extensible mark-up language (XML). EDI is often the focus of empirical research since it represents a stable technology that is well established in industry. Empirical literature has addressed EDI as both an application of a specific IOS technology and more generally as an enabler of information exchange. Early EDI research focused on the adoption of the technology (Crum et al. 1998; Crum et al. 1996; Johnson et al. 1992). Although trade publications predicted that EDI technology would be supplanted by the newer technologies, EDI continues to be a primary method of exchanging information in industrial supply chains. Firms already possess the necessary knowledge and infrastructure to exchange information using EDI and continue to leverage the resource. Trade journals report the continued and growing use of EDI (Brockmann 2003; Sliwa 2004). More recent research has focused on the use of EDI to exchange information that supports collaborative supply chain initiatives, and may include: VMI, JIT, and CRP.

This literature is critical for establishing the key mediating role of IT and information exchange in supply chains. IT is the enabler of information exchange and forms an efficient conduit that spans the boundaries of individual firms in the supply chain. The information that is exchanged through the use of IT supports many of the innovative processes used to improve supply chain performance.

2.4 Research Model Development

Theory and existing literature clearly recognize the critical role of information exchange in supply chain relationships. A gap in the literature is how information exchange is operationalized in empirical research. Information exchange has not been studied in a way that will enhance the understanding of how information exchange improves performance.

Research has addressed information exchange from many perspectives. Information exchange is often modeled as a binary measure where firms either exchange information or do not. Some studies have recognized that information is not homogenous and have measured the existence of multiple types of information. Such studies include whether demand forecast information is exchanged or whether point-of-sale information is exchanged but no more specific measures to capture the frequency or extent of the exchange.

Other research has begun to address the multi-dimensional features of information and proposed robust measures to capture some of the complexities of information exchange but has been limited to data collection from single firms. This dissertation combines and expands these approaches by identifying and testing objective measures of information exchange across multiple firms.

Early studies of information exchange technology focused on the adoption of IOS to coordinate the supply chain. Appropriate questions at the time where centered around whether firms were exchanging information through the use of IOS and if performance was effected. As such, basic binary measures and measures of the percentage of relationships that used the technology were appropriate to understand the diffusion of technology (Allen et al. 1992; Crum et al. 1998; Crum et al. 1996; Srinivasan et al. 1994; Zaheer and Venkatraman 1994).

As the use of information exchange through technology became evident, research expanded to identify characteristics of information exchange. In a study of the effects of information sharing strategies on supplier reliability, the type of information and direction of exchange were captured using binary measures (Walton and Marucheck 1997). This survey-based research measured information exchange as if the buyer shares forecasts, if the buyer shares planned production, if the buyer shares capacity information, and if the supplier shares planned production. The study concludes that relationships where buyers share forecast information experience lower supplier reliability than relationships where buyers share planned production information with suppliers. Sharing forecast information is less valuable than sharing production plans. These results support that what types of information are shared effects the performance outcomes. Additionally, these measures recognize that each firm can exchange information such that information flows in both directions across the supply chain.

The complexity of information exchange has been captured in some EDI studies which allow for the development of an understanding of the heterogeneity of how firms use information exchange. Facets of EDI usage that help measure these differences are the volume of exchanges through IOS, the different types of information exchanged through IOS (diversity), the number of trading partners connected through the IOS (breadth), and the extent to which the interfirm processes are intertwined (depth) (Massetti and Zmud 1996). Although the focus of the study was EDI use, the measures captured how the firms were using a specific IOS to manage their portfolio of trading partner relationships. Segregating exchange into multiple components allows researchers to address how each facet contributes to firm performance and their interaction can be considered. This dissertation adopts the multi-faceted approach and applies it specifically to the measurement of information exchange in supply chain relationships.

For the purposes of this study, information types are categorized as being either transactional or enhanced based on their content. This distinction between types of information that can be exchanged is modeled by Cachon and Fisher (2000). In their study, information exchange is categorized as *traditional* information sharing and *full* information sharing. Under their depiction of traditional information sharing, only order information was given to the supplier. Full information sharing is modeled as allowing the supplier visibility of the retailer's inventory levels. Their use of traditional information sharing is consistent with the transactional information identified in this dissertation.

This distinction has also been modeled where traditional information is compared with the sharing of additional downstream demand forecasts (Cachon and Lariviere

2001). The inclusion of additional types of non-order information gets to the issue of how diverse information is used in the supply chain.

Transactional information is used to support the order cycle and was described as having an electronic data processing orientation by Porter and Millar (1985). This information includes electronically exchanged requisitions, purchase orders, purchase order confirmations, invoices, and remittance advice documents. Exchanging these documents electronically reduces the processing costs for firms by eliminating mailing costs, eliminating mailing delay, eliminating the need to enter the data manually at the receiving site, and reducing data entry errors.

Information beyond order cycle information can be used to support the coordination of interfirm resources (Cachon and Fisher 2000; Cachon and Lariviere 2001). In a study of VMI processes, researchers recognized that information including forecasts, daily demand, inventory positions, and shipment information can be exchanged in order to improve supply chain performance (Angulo et al. 2004). In this dissertation, the additional information that can be used to support interfirm coordination is included as enhanced information. This depiction of enhanced information exchange is inclusive of the *full* information identified in both Cachon and Fisher (2000) and Cachon and Lariviere (2001).

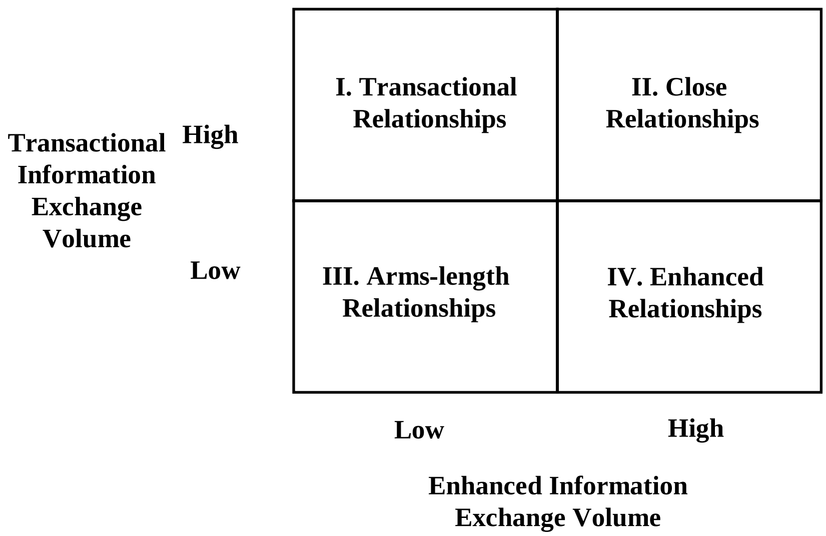
These two types of information exchange are modeled distinctly in research depending on the focus of the study. Exchanging enhanced information between a vendor and a retailer can include demand information, shipment information, inventory positions, and forecasts to support the decisions in a VMI process (Angulo et al. 2004).

The outcomes of these additional information flows include improved cash flow, shortened order cycle time, and increased firm competitiveness (Iacovou et al. 1995). Conversely, the exchange of transactional information is associated with improving the speed and accuracy of the order processing cycle. The electronic exchange of requisitions, purchase orders, and invoices lowers the cost of transacting but has minimal impact beyond the order cycle.

Firms may choose to exchange any combination of the various types of information. Since research has identified that performance outcomes are affected differently based on the types of information exchanged, one could expect that various combinations of information types will similarly affect performance outcomes (Cachon and Fisher 2000). These two dimensions of information exchange characteristics become the foundation for improving the understanding of information exchange in supply chain relationships.

To illustrate the theorized relationship between the exchange of transactional information and the exchange of enhanced information in trading partner relationships, Figure 2.2 provides a two-by-two matrix. The four quadrants identify four distinct combinations of exchange volume between transactional and enhanced information within trading partner relationships. The mean values of transactional information exchange volume and enhanced information exchange volume are identified for each technology champion firm. By comparing the exchange volumes for each trading partner relationship with the mean of the technology champion firm, relationships can be identified as operating either above or below the mean for each type. Trading partners that are above the firm mean for both transactional and enhanced information exchange are recognized as having closer relationships relative to other trading partners exchanging with the technology champion firm.

Figure 2.2 Information Exchange Matrix



The top-left quadrant, I Transactional Relationships, depicts a condition where the frequency of transactional information exchange is high and the frequency of enhanced information is low. In practice, this situation may occur when a commodity item is exchanged. Although the item may be needed often or it is requested by multiple business units within the organization, the information exchanged is oriented towards the order cycle and little if any additional information is exchanged. Such may be the case in a supply chain relationship for providing office supplies. The buying firm could create a contract that decentralizes the ordering process which allows each operating area to place orders with the office products supplier on an as-needed basis. This would potentially create a situation where order cycle information is exchanged at a high frequency. Once the items for the contract are identified and pricing / service expectations are agreed upon, minimal additional information would be required to support the relationship. Enhanced information such as production schedules, demand forecasts, and logistics documents are rarely shared in these commodity relationships because the cost of exchanging them is often greater than the value they add in managing basic commodity products. The supplier simply fills the order and delivers it based on a pre-determined service-level agreement.

The top-right quadrant, II Close Relationships, depicts a condition where both transactional and enhanced information are exchanged at a high volume. A high volume of transactional information is indicative of many interfirm orders being placed and filled. Trading partner relationships that exist in this quadrant may exchange commodity item or production materials that are supplied on a frequent basis. Materials supplied through a just-in-time process could represent items that are ordered on an hourly or daily basis for sequencing into the production cycle. Due to the critical nature of the items, additional enhanced information could be exchanged to synchronize production further down the supply chain. The exchange of additional information including demand forecasts, actual customer demand, production sequences, and inventory balances can enhance the planning process across multiple echelons of the supply chain.

The bottom-left quadrant, III Arms-length Relationships, depicts a condition where both transactional and enhanced information are exchanged at a low volume. These trading partner relationships are expected to represent non-critical items that are ordered on an infrequent basis. The items may be low in cost or low in usage which in either case would support infrequent ordering. Low cost items have a minimal effect on carrying costs relative to their ordering costs as modeled in the economic order quantity (EOQ) calculation and are often ordered in larger quantities less often. Similarly, low demand items would be ordered infrequently even in a just-in-time environment. Commodity or low-criticality items would be less likely to benefit from the exchange of enhanced information. In practice, these items might include maintenance, repair, and operations (MRO) supplies which are used to support the functions of the firm.

The bottom-right quadrant, IV Enhanced Relationships, depicts a condition where transactional information is exchanged at a low volume but enhanced information is exchanged at a high volume. The high volume of exchange for enhanced information would suggest that the items supplied through these trading partner relationships are critical in nature either due to their use in the process or their cost. The exchanging of enhanced information would support enhanced planning and synchronizing across interfirm processes. The combination of high enhanced volume with low transactional volume would suggest that the items are either ordered in bulk or not needed very often. In practice, these items may be direct materials that are used in production of the firm's product. Large quantities of critical inputs that are ordered infrequently may include raw materials that are ordered by rail car such as flour and sugar. Small quantities of critical inputs may include custom hydraulic equipment for large construction equipment. In either case, large volumes of planning and sequencing information may be exchanged to ensure that the input is available when needed, but minimal transactional information is exchanged due to the infrequent need to procure the items.

This matrix provides a grid though which information exchange can be observed to better understand how firms use information exchange strategically in their supply chain relationships. Based on the TCT theoretical lens and the extant literature on the use of IT-enabled information exchange, this dissertation will address the research question of how information exchange is associated with supply chain performance.

Chapter three describes the research setting and data that will be used to test hypotheses through studies developed in Chapters four and five.

Chapter 3: Research Setting and Data

This dissertation uses a unique dataset extracted from an established, electronically-mediated industrial exchange network. Where most previous studies have been limited to survey-based perceived measures of information exchange, simulation of information exchange, or analytical modeling of supply chain interaction, this study uses objective measures of actual exchanges of information between industrial supply chain participants.

This proprietary database has been made available by one of the largest EDI network providers in the industry. The data include summary volumes at a network, technology champion firm, trading partner, and dyadic level on a monthly basis for the years 2004 and 2005. Additional secondary data on firm performance and company specific data has been provided from Standard and Poor's Compustat database.

Interactions with this EDI network provider helped provided qualitative and quantitative information pertaining to this research. The qualitative information is used to help describe the context of the investigation of the research questions. Conversations with employees from the EDI network provider helped give great insight into the nature of the relationships between the technology champion firms and their trading partners. Although none of the qualitative information was used explicitly, it was used implicitly to help structure the research.

3.1 Use of Electronic Data Interchange Data for Empirical Research

For the purposes of this study, EDI is defined as a specific type of IOS which 1) exists between at least two organizations, 2) transfers data between independent application systems at each firm, 3) uses standardized data formats, and 4) transfers the data using telecommunication links (Iacovou et al. 1995; Pfeiffer 1992). EDI under this definition is a computer-based method of formatting and exchanging information that is relatively fast, accurate, and low-cost.

The benefits of technology adoption related to EDI implementation have been addressed in logistics and EDI literature. A survey of warehousing firms found that firms using EDI had a strategic impact by providing a greater (average) number of services to customers and by more easily accommodating special customer requests (Rogers et al. 1992). The use of EDI in an automotive setting resulted in a cost savings of between sixty and one hundred dollars per vehicle (Mukhopadhyay et al. 1995).

While early EDI studies focus on the growth and adoption of the technology, more recent research accepts the widespread use of EDI and instead focuses on the best use of the technology. For example, Subramani (2004) looks at how firms can extend EDI relationships to develop domain-specific knowledge and business-specific processes that create negative externalities for their competitors.

Researchers in IT, operations management, and logistics have viewed EDI as a specific application of IOS. This perspective contributes to the understanding of the use of IT as a tool for the exchange of interfirm information. Key EDI-based literature, methodology, and findings are summarized in Table 3.1.

Table 3.1 EDI Literature Review

Author (s)	Methodology	Major Findings
(Subramani 2004)	Empirical – Case study	• Suppliers benefit from EDI implementation when they use the integration to build business process specificity or domain knowledge specificity

(Machuca and Barajas 2004)	Empirical – Simulation	• EDI use contributes to cost savings and SCM improvements (reduces bullwhip)
(Hill and Scudder 2002)	Empirical – Survey	• EDI seen as a source of efficiency rather than integration • Firms are more accommodating to customer EDI than supplier EDI
(Mukhopadhyay and Kekre 2002)	Empirical – Archival data	• Use of integrated EDI results in more on-time payments and less credit orders • Customer driven EDI implementation results in greater benefits for the supplier • Supplier process specificity results in greater benefits for the supplier
(Angeles and Nath 2001)	Empirical – Survey	• Compatibility of trading partners is important for successful EDI implementation
(Raghunathan and Yeh 2001)	Empirical – Modeling	• Sharing of demand information improves the manufacturer's forecast accuracy • Information sharing decreases safety stock • Continuous replenishment programs benefit retailer and manufacturer by moving inventory faster
(Droge and Germain 2000)	Empirical – Survey	• The use of EDI and firm financial performance are positively related • Increased inventory is positively related to EDI, stable demand, small firm size, routine production technology and JIT usage
(Cachon and Fisher 2000)	Empirical – Modeling	• Use of IT to accelerate the flow of products is more valuable than using IT to expand the flow of information
(Lee et al. 1999)	Empirical – Case study	• Retailers who are forced to adopt systems can benefit if they reengineer their internal processes
(Crum et al. 1998)	Empirical – Survey	• Use of EDI is increasing • Customer service and marketing are implementation drivers • Use of transaction sets is concentrated • Stakeholders generally satisfied with EDI
(Williams et al. 1998)	Empirical – Survey	• EDI can be measured as a multi-dimensional technology • Longer use of EDI and increased investment increase the width, depth, and range of use
(Walton and	Empirical –	• EDI reduces uncertainty due to timeliness

Marucheck 1997)	Survey	and information flow • Demand information is negatively related to supplier performance • Production schedule sharing is positively related to supplier performance
(Crum et al. 1996)	Empirical – Survey	• Adopters and non-adopters differ on environmental and organizational factors • Slow increase in use of new transactions • Customer show higher EDI satisfaction than carriers (suppliers)
(Massetti and Zmud 1996)	Conceptual	• Identified four dimensions of EDI usage: volume, diversity, breadth, depth
(Mukhopadhyay et al. 1995)	Empirical – case study	• Real dollar savings for production are attributed to the use of EDI. • Savings from inventory carrying, obsolete inventory, premium freight, paperwork
(Wang and Seidmann 1995)	Empirical – Modeling	• Supplier's use of EDI creates positive network externalities for himself and negative network externalities for its competitors • Buyer pays a premium for EDI integrated supply
(Iacovou et al. 1995)	Empirical – Structured Interviews	• For small firms, pre-adoption awareness of EDI benefits is low • External pressure from customers and competitors drives adoption of EDI • Implementation cost is a barrier for small firm adoption of EDI
(Srinivasan et al. 1994)	Empirical – case study	• Suppliers with integrated EDI have lower shipment errors
(Zaheer and Venkatraman 1994)	Empirical – Survey	• Asset specificity is positively related to the degree of electronic integration • Trust is positively related to the degree of electronic integration • Reciprocal investment is negatively related to the degree of electronic integration
(Allen et al. 1992)	Empirical – Survey	• Large carriers are expanding EDI usage more than small carriers • EDI is used more without contracts than with contracts • Carriers implement EDI to meet customer requirements and improve customer service
(Rogers et al. 1992)	Empirical –	• Warehousing firms offering EDI services

	Survey questionnaire	are better able to accommodate customer requests • Warehousing firms offering EDI technology provide more services to their customer than non-EDI firms
(Johnson et al. 1992)	Empirical – Survey	• 56% used firm-specific (custom) formats • Meeting customer requirements/customer service was greatest benefit of implementation
(Crum and Allen 1990)	Empirical – Survey	• EDI usage positively correlated with supplier base reductions

3.2 Formatting Standards and Electronic Intermediaries

EDI provides standard communication formats that allow companies to universally exchange data. An EDI standard is a specific format for translating discrete business documents into electronic messages. Each business document type is defined using an EDI standard format. Purchase orders, invoices, shipping notices, demand data and hundreds of other business documents are specifically defined for transfer between companies. Through the use of standardized format, all purchase orders will have the same electronic layout. This standardization allows the purchase order to be created and interpreted by all firms using the format standard. Firms that use the EDI standards can more easily exchange information with external firms since the published standards specify how the data is interpreted for use between firms.

There are currently two organizations recognized for developing EDI message standards. The American National Standards Institute (ANSI) develops domestic standards and the United Nations (UN) creates international standards. The UN standards establish criteria for standard EDI messages for Administration, Commerce, and

Transport (EDIFACT) (Massetti and Zmud 1996). The ANSI X12 and the United Nations EDIFACT standards are both used for the formatting of electronic documents using EDI (Zuckerman 2004). Domestically, the ANSI X12 standard for EDI business documents is most popular as it is specifically designed to support business transactions in North America. The United Nations EDIFACT standard is used for international EDI transactions. Alternative formatting methods include XML and relation specific messaging formats (Zuckerman 2004). Although low set-up and implementation costs are making alternative formatting methods more popular, their lack of standardization limits their effectiveness.

3.2.1 EDI Exchange Networks

For the purposes of this study, the sponsoring firm will be called the technology champion firm which corresponds to other research that identifies the sponsor as the relationship initiator (Iacovou et al. 1995; Truman 1998). Sponsor firms participate in the exchange of information and take a leadership role in the development, maintenance, and expansion of the IOS with their trading partners. Their customers and suppliers that join the EDI network are identified as participants, adopters or simply trading partners (Iacovou et al. 1995). For the purposes of this study, trading partner will be used to describe the firms that were invited to join the network by the technology champion firm.

3.2.2 Establishing and Maintaining an Electronic Network

The exchange of EDI documents can be arranged directly between firms or by using an EDI service provider as an intermediary. The service provider offers technical support and operates the exchange network. Many firms seek the services of EDI intermediaries to avoid the development and maintenance costs related to creating proprietary communications networks. Researchers note that EDI implementation costs create a technology barrier as EDI champion firms attempted to expand the technology to their trading partners (Walton and Marucheck 1997). Value-added network providers (VANs) reduce the technology barrier by becoming electronic post offices for firms that do not want to build and maintain their own proprietary EDI communication networks. A firm choosing to use an integrator to implement EDI-based transactions with its trading partners would select a VAN, which in turn, works with the sponsor's trading partners to form electronic linkages. Once the trading partner joins the electronic network, the VAN serves as a clearing-house for all EDI transactions between the sponsor firm and its trading partners. The VAN is responsible for the high-speed connectivity, security, training, and data format support to ensure compliance with various EDI standards.

EDI is subject to network externalities such that the benefits to sponsors are increased as additional firms adopt the technology (Shapiro and Varian 1998). Growth of the EDI network allows sponsors to transact with more trading partners and reduce the cost of maintaining alternate parallel systems to transact with non-EDI-capable trading partners (Iacovou et al. 1995). Johnson et. al (1992) aptly note that firms are increasing their use of EDI by getting more trading partners to use EDI and by expanding the types of information exchanged using EDI.

Although adoption of EDI and growth of the EDI network are in the best interest of the technology sponsors, many trading partners are reluctant to adopt the technology. Technology diffusion research recognizes that smaller firms may be at a disadvantage in adopting EDI. Studies focused on the diffusion of EDI technology recognize that the cost of EDI implementation can deter the adoption of EDI by some firms (Iacovou et al. 1995). Three factors have been identified for their effect on EDI adoption for small firms: perceived EDI benefits, organizational readiness, and external pressure (Crum and Allen 1990; Iacovou et al. 1995). Perceived EDI benefits are the recognition by a firm's management that implementing EDI provides a relative competitive advantage. Organizational readiness refers to the firm's technical and financial resources that can be allocated to EDI implementation. External pressure refers to influences outside of the firm that encourage the adoption of EDI. These external influences can originate with competitors or trading partners. Through an empirical study of seven companies, researchers found that the strongest influence of small firm adoption of EDI was external pressure from trading partners (Iacovou et al. 1995). Firms that were highly dependent on their EDI champion trading partners showed the highest likelihood of EDI adoption. In the same study, results indicated a positive relationship between perceived benefits and adoption but mixed results for the relationship of organizational readiness and EDI adoption.

The pressure from sponsor firms to implement EDI has often been identified as a driver of EDI adoption by trading partners. As one might expect, meeting a customer requirement was one of the most important reasons that trucking firms implement EDI (Allen et al. 1992; Johnson et al. 1992). Moreover, firms often couple the use of EDI with other strategic initiatives such as the reduction of trading partners and the use of longer-term contracts (Allen et al. 1992; Crum and Allen 1990).

Although trading partners are increasingly migrating to the Internet to support EDI transactions, their interactions with the technology champion firms are still captured in this dissertation. The full-service integrator providing the data for this study supports both proprietary communications links as well as communication through existing Internet channels using the AS2 specification. AS2 is a relatively new specification that is becoming the standard for securely transporting EDI data through the Internet. Firms have been expanding their use of AS2 as a way to reap the benefits of standardized EDI formatting while avoiding the cost of using a proprietary communications network. Existing EDI integrators often offer software and hosting services for Internet EDI in order to meet customer demands for hybrid solutions. The technology champion firms in this study are exchanging EDI documents through either the proprietary VAN network or are using Internet EDI. Whether a technology champion firms uses the proprietary communication network or the Internet to connect with their trading partners is immaterial since the data is captured as it is routed to the electronic mailbox. In other words, regardless of the network that transports the EDI information exchange (VAN or Internet), the interaction with a technology champion firm and its trading partners is captured by examining information sent to and from the technology champion's EDI mailbox.

3.3 Units of Observation

This dissertation adopts two distinct units of observation. The first unit of observation is used in Chapter 4 and focuses on the exchange dyad. Each dyad consists of a technology champion firm and one trading partner. Using this unit of analysis allows for the exploration of information exchange within a specific supply chain relationship. The second unit of observation is adopted in Chapter 5. This unit of observation is the technology champion firm. This single firm level unit of observation supports the exploration of how a firm's use of the technology affects its performance.

Both analyses focus on the inter-firm information exchanged through an EDI-based trading network. The information exchange transactions on this trading network during a twenty-four month period provide the data for both analyses. This proprietary longitudinal dataset includes observations of the electronic transactions for thirty-nine publicly traded technology champion firms and their EDI connected trading partners. These thirty-nine focal firms are the EDI technology champions that formed initial relationships with the EDI integrator and then enlisted the participation of their trading partners. The EDI integrator coordinates with each of the technology champion firm's trading partners to create a telecommunications link either through a proprietary communications network or an alternate public network such as the Internet.

3.3.1 Firms in the Network

The technology champion firms in this trading partner network represent a broad range of industries. Based on the two-digit SIC code, the thirty-nine technology champion firms are distributed across three echelons of the supply chain (manufacturing, wholesale trade, and retail trade). Of the thirty-nine firms, twenty-three of them are manufacturers, eleven are retailers, and five are wholesalers.

The dataset provided by the EDI integrator includes all EDI transactions for the years 2004 and 2005 for the technology champion firms. Researchers have noted that firms can employ multiple methods and technologies to exchange information with their trading partners (Vickery et al. 2004). This being the case, the EDI network which provided the data may not be the primary exchange technology for a particular technology champion firm. In situations where the focal EDI network is not the primary exchange technology, changes in the data exchanged through the network may be confounded by the use of alternate channels. Since the services provided by the EDI integrator are scalable, technology champion firms use the network in various ways to support their business needs. Some technology champion firms use the network for only specific transaction types or relationships. Other technology champion firms use the network as their primary mode of interfirm communications. The EDI integrator was not able to fully assess the champion firm's use of alternate methods or strategy in using this network. To minimize the effects of including firms where alternate technologies may be in place, technology champion firms were eliminated from the study if they did not transact order cycle data through the observed network. An assumption was made that if order cycle transactions are not being exchanged on this network then the firm must be using at least one other primary channel to transact in the supply chain. A test was conducted to verify that order related data was transacted by the technology champion firm during the study period. If the champion firm did not transact any order cycle documents with its trading partners at any time during the study period, they were eliminated from study. The resulting 39 technology champion firms included in this study represent 23 manufacturers, 5 wholesalers, and 11 retailers.

The EDI integrator noted that technology champion firm relationships may vary by trading partner. As such, the potential exists that for an individual trading partner relationship, alternate technologies and communications methods may be in place. If a particular technology champion firm-trading partner dyad does not use this network as their primary exchange channel, any measures made from observations of this network may be biased. To minimize any potential confounding effects from unobserved information exchange, each dyadic relationship was analyzed to ensure that order cycle data was transacted by the dyad and that the information exchange was reciprocal. The presence of order cycle information exchange within the dyad provides an indication that the observed network at least supports the foundational electronic data processing functions of the dyad. By confirming the reciprocal exchange of information within the dyad, there is an increased likelihood that the observations represent a fully functioning supply chain relationship where information is shared by both parties. For the purposes of this analysis, all observed trading partner relationships include order cycle transactions and a reciprocal sharing of information across the dyad.

The study period covers twenty-four months, starting in January 2004 and ending in December 2005. Transactional data are collected and transferred to a data warehouse by the EDI integrator at the close of each calendar month. Monthly extracts were made from the EDI integrator's data warehouse using Business Objects. Each observation in the extracted files contains unique technology champion firm-trading partner volumes for each transaction type during the period. A sample of the data is shown in Table 3.2; the EDI integrator transaction database provides observations at a summary level for each dyadic relationship on the network.

Table 3.2 Sample of Trading Partner Network Data

Observation	Technology Champion Firm	Send / Receive	Trading Partner	Period	EDI Transaction ID	Transaction Count
1	X	S	A	Jan. 2005	850	23
2	X	S	A	Feb. 2005	304	30
3	Y	R	B	Feb. 2005	610	341
…n						

As illustrated in Table 3.2, each observation identifies the technology champion firm and its exchange with a specific trading partner during the period. The identities of the technology champion firms are masked throughout the analysis under the terms of the non-disclosure agreement with the EDI integrator. The identities of the trading partner firms were not supplied by the network provider. Each observation then identifies whether the technology champion firm received (R) the EDI document or sent (S) the EDI document. The EDI integrator assigns unique mailbox numbers to each of the trading partners to facilitate the routing of EDI messages. The period is the abbreviated month and year of the transaction. The EDI Transaction ID is an alpha numeric value that identifies either an ANSI X12 standardized message, an EDIFACT standardized message, or a generic value identifying a firm specific custom message. Examples of standard EDI transactions under the ANSI X12 and United Nations EDIFACT message types are included in Appendix A.

The termination study developed in Chapter 4 uses the monthly observations to support the analysis of information exchange characteristics and relationship termination. For the technology champion firm performance analysis developed in Chapter 5, the monthly information exchange data is aggregated to the calendar quarter. This aggregation allows for the matching of firm quarter information exchange measures to the publicly available firm financial data.

Technology champion firm's financial and operational measures were obtained from Standard and Poor's Compustat financial database. Public companies provide selected operational and financial information on a quarterly and annual basis. The Compustat data have been extracted and matched for all thirty-nine technology champion firms for each of the eight quarterly EDI observation periods.

3.3.2 Key Constructs

The three dimensions of transactions outlined by Williamson (1975 and 1985) are found within the measures commonly used in the research of information exchange and EDI adoption. Researchers have identified some characteristics of information exchange including information frequency, information diversity, and degree of customization (Crum et al. 1998; Massetti and Zmud 1996; Srinivasan et al. 1994; Williams et al. 1998). These richer measures of information exchange have extended research beyond the foundational level of binary measures which only measured if trading partners shared information. Greater interest is now focused on what information is exchanged and how the exchange affects supply chain performance (Saeed et al. 2005). This dissertation builds on these empirical measures and extends them to recognize the directional properties of information exchange and the diversity of information exchange.

Directionality of Information Exchange

Since this dataset provides a unique view of supply chain information exchange, the standard frequency measures of TCT and information exchange research are being combined and augmented to recognize not only the number of exchanges each month (frequency) but also the direction of the exchange. Since direction of exchange is sensitive to the position of the focal party within the exchange relationship, this study will maintain all statements about direction of exchange based on the perspective of the technology champion firm. Information exchange noted as “Send” represents information transferred from the technology champion firm to the trading partner. Information exchange noted as “Receive” represents information transferred from the trading partner firm to the technology champion firm as illustrated in Figure 3.1.

Figure 3.1 Information Exchange Directionality

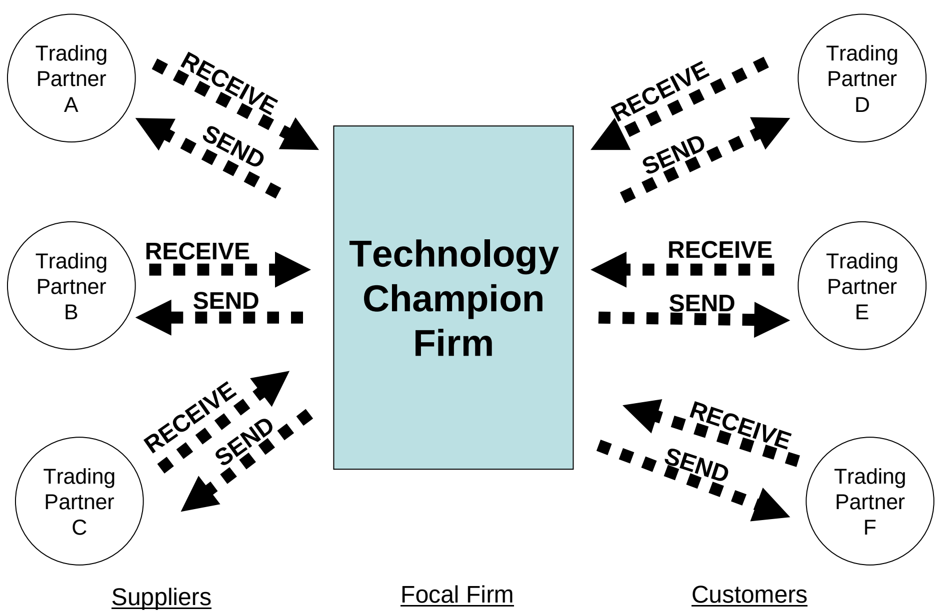


Figure 3.1 has been labeled to associate the electronic exchange network with a traditional supply chain configuration. Specifically, the roles of supplier, focal firm and customer have been noted to illustrate the flow of information across the network. The roles of participants in the electronic exchange network used in this dissertation are not specified since the roles are based on each unique transaction rather than on the specific location of a firm within the supply chain. Potentially, a trading partner may supply raw materials to a focal firm and then in a later transaction purchase finished goods from the same focal firm, thus the trading partner's role could change from supplier to customer depending on the transaction. What is unique in the structure of this network is that technology champion firms that are retailers predominately interact only with their suppliers through the exchange network. Consumers do not use EDI value added networks to transact with retailers.

<u>Information Type</u>

The level of detail available in an EDI enabled exchange network allows for the categorization of information by type as well as volume. Each transaction is identified with a transaction code to identify the functional process to which the information belongs. The sending firm identifies the transaction type so that the receiving firm knows where to route the information and which EDI standard to use when accepting the data into their system.

The standardized formatting and identification of EDI transactions allows the transactions to be identified by the type of information they include. A preliminary categorization of the EDI standard transaction types into the two previously defined categories was provided to the EDI network integrator. Account executives then responded individually based on their knowledge of how the transaction types are used on the network. Modifications were made to the categorization and the revised categories were returned to the network integrator for review. The final form of the grouping used for all subsequent analysis is included in Appendices B and C.

The use of standardized transaction types is a key element of EDI networks. In an EDI enabled network, purchase orders are identified with transaction code 850. The EDI ANSI X12 standard for transaction code 850 provides details of field locations and formats such that the 850 transactions from any trading partner can easily be incorporated into the host firm's computerized order processing system. As described in Chapter 2, these transaction codes are used in this study to group information exchange documents as being either transactional or enhanced.

3.4 Descriptive Statistics

3.4.1 Descriptive Statistics of the Exchange Network

The EDI exchange network provides a unique view of the electronic information exchanges for thirty-nine technology champion firms and their 18,644 trading partner relationships. Over a two-year period, there are 320,788,026 business documents exchanged in this network. Based on the categorization of information exchange provided in Chapter 2, these exchanges are representative of both the transactional and enhanced types. As described in Table 3.3, a small percentage of the documents exchanged (2%) could not be identified with either category. This occurs when non-standard EDI transactions are defined by a technology champion firm or within a specific dyad. EDI participants may use non-standard transaction codes to identify documents that are unique to their trading partner relationships. Seventy-five percent of the transactions are categorized as transactional exchanges. Twenty-three percent of the documents exchanged are categorized as enhanced information exchange. The remaining two percent were not mapped to either primary group and are identified as miscellaneous.

Table 3.3 Network Descriptive Statistics

Technology Champion Firms	39
Trading Partner Relationships	18,644
Transactional Information Exchanges	241,014,613
Enhanced Information Exchanges	72,927,949
Miscellaneous Information Exchange	6,845,464
Unique Document Types	352

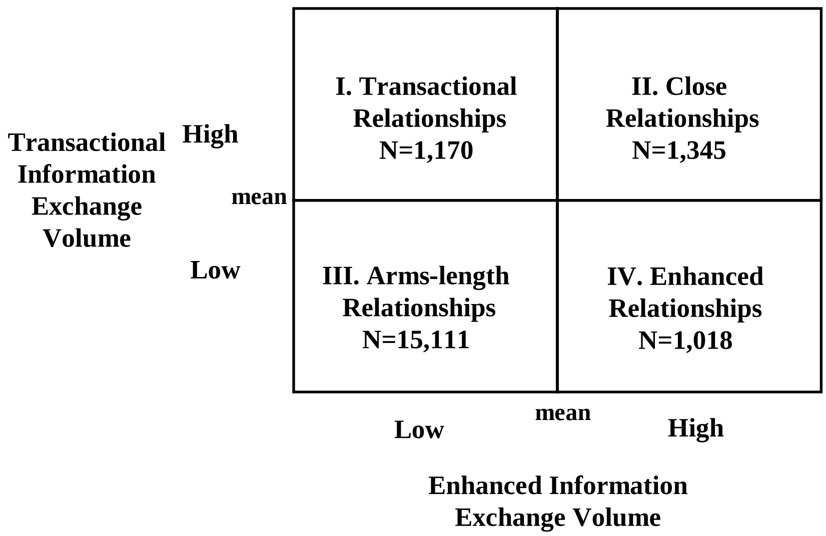
Since the data aggregated monthly by the EDI integrator is oriented to the technology champion firms, the number of trading partners on the network will be slightly overstated. This occurs when a technology champion firm is a trading partner of another technology champion firm. When a technology champion firm is a supplier or customer of another technology champion firm, they will be included as both a technology champion firm and a trading partner. This "double counting" is not be an issue for two reasons. First, the firm should be treated differently in each observation because of the role it plays in the information exchange—either as the technology champion or as the trading partner. Second, the double counting has minimal impact on the study outcomes due to the large number of trading partners and the relatively small number of technology champion firms.

3.4.2 Descriptive Statistics of the Supply Chain Echelons

Within the network, technology champion firms represent three distinct echelons of the supply chain (manufacturing, wholesale trade, and retail trade). Using the information exchange matrix introduced in Figure 2.2, the portfolio of trading partner relationships can be characterized for each echelon of the supply chain. By considering the types of information exchanged with each trading partner, a descriptive analysis provides some understanding of how each echelon uses information exchange to interact with their pool of trading partners.

Trading partner relationships can be categorized using the typology identified in Figure 2.2. By comparing the volume of transactional and enhanced information exchange for each trading partner relationship to the mean for the technology champion firm, each trading partner relationship can be associated with a quadrant in the information exchange matrix. Figure 3.2 shows the distribution of the trading partner relationships in the network based on the information exchange quadrants.

Figure 3.2 Trading Partner Relationship by Information Exchange Quadrant



Each trading partner relationship is associated with a quadrant of the matrix based on the mean exchange volume of the technology champion firm in the relationship. As shown in Figure 3.2, eighty percent of the trading partner relationships in the network are characterized as arms-length based on their relatively low volumes of transactional and enhanced information exchange. Conversely, seven percent of the trading partner relationships in the network are characterized by a high volume of both transactional and enhanced information exchange as identified by the III Close Relationships quadrant. This distribution of relationships supports research which suggests that firms are showing a tendency toward managing their trading partner relationships as a portfolio consisting of a wide array of types (Krapfel et al. 1991). These relationship types are often characterized by their closeness and their ability to support strategic initiatives.

Technology champion firms vary in their use of close and arms-length relationships. From a supply chain echelon perspective, manufacturing firms have the lowest percentage of arms-length relationships of any of the three echelons but it still represents seventy-five percent of their relationships. Retail trade firms have the highest percentage of arms-length relationship at eighty-two percent.

Expanding this analysis to consider the performance of trading partner relationships operating in each quadrant may provide insight into a relationship between information exchange characteristics and relationship performance. Strategy research has recognized survival as a measure of firm performance (Shaver and Flyer 2000). The importance of relationship survival is echoed in marketing literature which recognizes that firms are reducing the number of trading partners they exchange with in order to develop competitive benefits with selected trading partners (Spekman 1988). Additionally, researchers have noted that over time, dissatisfied exchange partners will leave the relationship to seek new partners (Hirschman 1970). Subsequently, trading partners can benefit by avoiding termination.

Performance in an electronic exchange network can be observed as exchange continued over time. As illustrated in Table 3.4, trading partner relationships characterized by low levels of transactional and enhanced information exchange experience the highest termination rates. Termination here is measured by exchange occurring in 2004 but not in 2005. The unit of observation is limiting since it creates the possibility that a trading partner relationship may actually be terminated in 2004 which would generate low volumes of information exchange which could potentially assign the relationship incorrectly to the III Arms-length quadrant. Table 3.4 does provide some initial insight into the variation of relationship termination rates across the network. It should be noted that the absence of information exchange through the network is assumed to indicate the termination of the business relationship. The potential to assign relationships to incorrect quadrants is addressed in subsequent chapters by using multiple methods which evaluate information exchange characteristics and performance on a month-to-month and quarter-by-quarter basis. The use of smaller discrete time period observations allows for a closer association of information exchange characteristics and the performance outcomes.

Retailers on average show the highest termination rate with trading partners characterized as arms-length (41%) and lowest termination rate with trading partners characterized as close relationships (8%). Manufacturers and wholesalers show similar differences between arms-length and close relationships however, wholesalers on average have the lowest termination rate with trading partner relationships characterized as transactional (3%). Additional analysis will be conducted in each study to explore how the effects of information exchange may vary based on the location of a firm within the supply chain.

Table 3.4 Average Termination Rates by Firm (From 2004 to 2005)

Firm	I. Transactional Relationships		II. Close Relationships		III. Arms-length Relationships		IV. Enhanced Relationships		Overall	
	Termination Rate	N	Termination Rate	N	Termination Rate	N	Termination Rate	N	Termination Rate	N
Manufacturer A	4%	47	16%	19	41%	354	0%	12	35%	432
Manufacturer B	0%	6	0%	1	10%	41	0%	4	8%	52
Manufacturer C	0%	4	0%	10	14%	69	33%	3	12%	86
Manufacturer D	0%	3	0%	7	58%	45	0%	4	44%	59
Manufacturer E	0%	11	0%	23	19%	223	4%	49	14%	306
Manufacturer F	0%	1	33%	6	29%	52	0%	2	28%	61
Manufacturer G	7%	15	0%	8	57%	83	33%	3	45%	109
Manufacturer H	4%	23	0%	8	17%	88	7%	14	13%	133
Manufacturer I	23%	22	0%	3	35%	83	33%	18	32%	126
Manufacturer J	0%	4	0%	1	14%	22	0%	3	10%	30
Manufacturer K	100%	14	100%	5	100%	110	100%	5	100%	134
Manufacturer L	22%	28	18%	11	49%	205	20%	5	44%	249
Manufacturer M	11%	18	18%	6	32%	146	57%	7	30%	177
Manufacturer N	20%	5	17%	11	41%	63	0%	6	34%	85
Manufacturer O	0%	1	0%	1	11%	19	25%	4	12%	25
Manufacturer P	0%	7	0%	3	10%	96	0%	6	9%	112
Manufacturer Q	2%	62	2%	96	9%	481	0%	57	7%	696
Manufacturer R	0%	2	0%	6	25%	81	0%	5	22%	94
Manufacturer S	0%	4	0%	9	19%	31	0%	26	8%	70
Manufacturer T	11%	9	0%	1	29%	21	33%	3	24%	34
Manufacturer U	20%	10	13%	15	22%	91	25%	4	21%	120
Manufacturer V	67%	3	0%	0	8%	13	20%	10	12%	26
Manufacturer W	0%	6	0%	1	10%	41	0%	4	8%	52
Mfg Average	12%	13	8%	11	30%	107	10%	11	25%	142
Wholesaler A	0%	23	3%	32	32%	324	0%	9	27%	388
Wholesaler B	2%	41	5%	19	35%	251	29%	14	29%	325
Wholesaler C	10%	21	18%	17	34%	219	18%	11	30%	268
Wholesaler D	0%	24	2%	57	17%	418	2%	55	13%	554
Wholesaler E	3%	64	3%	58	16%	827	4%	53	14%	1,002
Whslr Average	3%	35	4%	37	23%	408	7%	28	19%	507
Retailer A	13%	23	5%	42	23%	397	7%	15	20%	477
Retailer B	0%	63	2%	63	14%	303	5%	41	10%	470
Retailer C	0%	17	0%	14	0%	189	0%	1	0%	221
Retailer D	12%	265	14%	185	48%	2,203	29%	90	42%	2,743
Retailer E	17%	18	11%	18	28%	198	0%	1	26%	235
Retailer F	20%	5	0%	3	46%	99	0%	1	43%	108
Retailer G	43%	7	0%	3	90%	68	40%	5	80%	83
Retailer H	12%	222	7%	492	49%	4,484	9%	316	41%	5,514
Retailer J	11%	9	19%	27	33%	255	8%	12	30%	303
Retailer K	4%	51	3%	31	27%	1,050	1%	113	23%	1,245
Retailer L	4%	12	0%	33	28%	1,368	0%	27	27%	1,440
Rtlr Average	10%	63	8%	83	41%	965	10%	57	35%	1,167
Overall	10%	1,170	7%	1,345	36%	15,111	10%	1,018	31%	18,644

Termination Rate is based on relationship termination prior to January 1, 2005

One might assume that the trading partner relationships in the III Arms-length quadrant provide sporadic materials on an as-needed basis since they are characterized by low levels of transactional exchange, however, there are other trading partner relationships with similar low levels of transactional information exchange that experience significantly lower levels of termination. Trading partner relationships in the IV Enhanced quadrant are characterized by similar low levels of transactional information exchange but experience termination rates below ten percent across any of the three echelons. From an information exchange perspective, the difference for trading partner relationships in the IV Enhanced quadrant also includes the exchange of relatively high levels of information beyond what is exchanged to support the routine order cycle. This dissertation will develop this relationship between termination rates and the closeness of trading partner relationships.

3.5 Research Question

Theory and extant research recognize the critical role of information exchange in supply chains. The descriptive analysis in this chapter indicates that technology champion firms vary in how they use information to interact with their trading partners. Firms differ in their use of distinct types of information, volumes of information exchange, and their balance between sending and receiving information.

Theory supports that information exchange affects the performance of both relationships and individual firms. This descriptive analysis supports that based on relationship termination, performance varies with information exchange characteristics when relationship performance is defined as survival. The literature is not clear on what characteristics of information exchange affect supply chain performance.

This study proceeds with Chapter 4 by developing hypotheses and empirically testing relationship performance based on relationship termination. This approach focuses specifically on how information exchange affects trading partner relationship survival.

Chapter 4: Trading Partner Relationships

4.1 Introduction

This part of the dissertation contributes to the literature by providing an empirical examination of the effects of information exchange on trading partner relationship termination. Specifically, this study provides a longitudinal examination of trading partner relationship termination in an electronically-mediated B2B network. The network includes observations of trading partner relationships across the manufactures, wholesalers and retailers.

The level of analysis of this study is the trading dyad. Dyadic studies have been of great interest to researchers since it is the smallest relational unit in the supply chain where interfirm actions can enhance or cripple the supply chain (Anderson et al. 1994; Dwyer et al. 1987; Dyer and Singh 1998; Svensson 2004; Whipple et al. 2002). Research into supply chain relationships often takes either a buyer's or seller's perspective and focuses on the performance of one party. This dyadic study uses termination as the performance measure recognizing that both participants invest in the business relationship and neither achieves future relational benefits if the relationship is terminated. By adopting a dyadic level of analysis, this study captures the unique characteristics that are often overlooked in a firm-level or industry-level analysis.

The performance measure of interest in this study is relationship termination. Relationship termination is particularly pertinent as a performance measure when the unit of analysis is a relational dyad. Research has recognized that there is value in supply chain relationships that endure over time. Relationships between supply chain participants are noted for creating sustainable competitive advantage because of their ability to develop causal ambiguity and time compression diseconomies (Dierickx and Cool 1989; Dyer and Singh 1998). Causal ambiguity develops in relationships due to the complex nature of the relationship whereby competitors can observe the relationship but still not fully duplicate it such that they can obtain the same competitive results. From an interfirm process orientation, time compression diseconomies recognize that the benefits of the relationship are built over time and that if a competitor desires to duplicate the relationship they will incur greater costs to develop the relationship quickly. Additionally, firms often allocate resources to develop relationships and there is an expectation that the initial investment will provide benefits for an extended period of time (Jackson 1985). When firms invest in relationships and those relationships are terminated, they return to the market to invest in developing new relationships. Firm survival is often the focus of strategic management research due to the inherent interest academically and practically in avoiding termination or exit from a market (Cottrell and Nault 2004; Disney et al. 2003). This study focuses on relationship termination as a performance measure and applies it to the analysis of dyadic supply chain relationships.

There are several contributions of this examination into the use of information exchange in supply chains and its impact on relationship termination. First, this study differentiates between the types of information exchanged within B2B industrial supply chain relationships. The effects of transactional information exchange are separated from the effects of enhanced information exchange. Second, objective measures of longitudinal information exchange are captured and used for empirical research. Third, the use of two statistical methodologies, provides an improved understanding of how individual firms and their exchange of information is associated with the termination of their trading partner relationships. These results are expanded by associating the relational outcomes of firms in different echelons of the supply chain (i.e. manufacturers, wholesaler, and retailers) with their use information exchange in their trading partner relationships.

The remainder of this chapter is organized as follows. Section 4.2 provides a development of hypotheses; section 4.3 develops the research methodology; section 4.4 provides the model results and hypotheses tests; section 4.5 discusses the contribution and limitations; and section 4.6 concludes this portion of the dissertation.

4.2 Development of Hypotheses

From TCT, transactional volume is an important part of understanding the closeness of a supply chain relationship. Webster (1992) recognized that interfirm transactions were migrating from discrete market transactions toward relational exchange where firms experience recurring transactions over time. As firms move away from discrete market transactions, they have the potential to identify new opportunities through coordination with their trading partners as they understand each other's needs more through repeated exchanges (Webster 1992).

In an arms-length market transaction, there is minimal expectation of future exchange so the motivation to perform is limited. Under such conditions, trading partners may choose to not fulfill the contract with limited ramifications. Arms-length transactions are characterized by: limited investment of specific assets, minimal information exchange, low levels of interdependence, low transaction costs, and minimal investment in governance structures (Dyer and Singh 1998; Williamson 1985). The result is that the buyer experiences minimal costs related to selecting a new supplier for subsequent purchases – there is nothing unique about the relationship. In this situation there is no commitment or loyalty to the relationship which allows either party to exit the relationship without expression of cause or justification (Hirschman 1970).

As transactions move from discrete to recurring, the foundations of a relationship emerge (Webster 1992). A distinction between discrete and relational exchange then is the repetition of procurement exchanges over time. As transactions move away from discrete market events, there is the potential to develop relational aspects including trust, dependence, and loyalty (Hirschman 1970; Morgan and Hunt 1994). The replacement of market transactions with multi-year contracts further creates an environment of lock-in whereby switching costs are legally imposed to minimize exit (Shapiro and Varian 1998). Moving away from market transactions introduces a longer-term orientation and closer relationships (Kalwani and Narayandas 1995).

As dependence increases, the opportunity for trading partners to act in their own best interests increases. A sole supplier of an input has the opportunity to extract additional margin with less chance of repercussions in the short-run. To ensure against such actions, firms may increase monitoring mechanisms or realign their relationships in order to minimize risk (Williamson 1975). At higher levels of transactional volume, termination may actually become a greater risk such that a non-linear relationship exists between transactional volume and relationship termination.

To test the combination of these opposing forces, a non-linear hypothesis is put forth as,

Hypothesis 1: There is a u-shaped relationship between transactional information exchange volume and relationship termination.

As relationships move beyond a basic transactional focus, firms can create unique competitive advantages (Dyer and Singh 1998). By exchanging information, firms identify opportunities to combine complementary resources. A manufacturer, The Campbell Soup Company, formed ties with their retailers beyond the sales-to-purchasing interface (Lee et al. 1999). These additional linkages provided information that supported the development of processes whereby Campbell's could monitor end customer demand and provide inventory management services for their retailers. Campbell's enhanced their relationship by embedding interfirm routines that provided unique value to the retailer. The retailer experienced improved performance in the form of lower stockouts and higher inventory turnover.

Research has also recognized that too much information can be detrimental to performance. Through a simulation, researchers allowed for large volumes of point-of-sale information to flow upstream in the supply chain (Steckel et al. 2004). Results of their study indicate that depending on the demand variability, additional information may not aid the planning process but actually diminish performance by distracting upstream decision makers. One might recognize the potential to overload a relationship with information when IT is used to mediate the exchange. The marginal cost of sending additional information is low once the fixed costs of formatting the data and establishing the network are incurred. One might argue that the additional information could be ignored but the filtering of information required to identify the pertinent information may still diminish performance as previously found. Receiving an overload of information can be detrimental to performance either because the receiver must filter the information to identify the pertinent parts or may become frustrated and ignore all the information from the sender.

This diminishing affect of too much information suggests that there is a non-linear relationship between the volume of enhanced information exchange and relationship performance. Thus,

Hypothesis 2: There is a u-shaped relationship between enhanced information exchange volume and relationship termination.

Enhanced information may be more indicative of a close relationship and, therefore, will decrease the likelihood of relationship termination. Strategy research recognizes the value of information exchange beyond the sales-to-purchasing interface (Dyer and Singh 1998). This enhanced information exchange occurs when multiple interorganizational functions integrate. In practice, this occurs when the serial interface between the marketing function of the selling firm and the sales function of the buying firm is augmented by the creation of parallel exchanges between multiple operational areas in each firm. These multiple functional interfirm interfaces are noted as a source innovation such that new products, services, and technologies are developed (Dyer and Singh 1998). The sales-to-purchasing interface is supported by routine order cycle document exchanges (requisitions, purchase orders, invoices, etc.). Exchanges between the functional areas of two firms would be supported through the exchange of additional information described in this study as enhanced (demand data, forecasts, inventory levels, forecasts, production schedules, etc.).

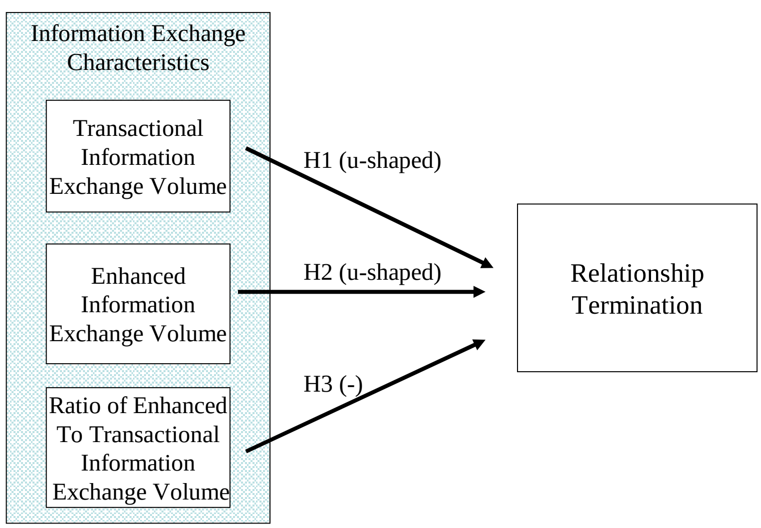
Given the additional functionality supported by the exchange of enhanced information, one could expect that a single procurement transaction might be the result of the multiple exchanges of enhanced information. A purchase order could be preceded by the exchange of demand forecasts, production schedules, and inventory positions which improve the quality of the purchase decision. After ordering, additional information on shipment schedules, production sequences, and quality control tests may be provided. This post-sale information provides additional value by smoothing the integration of the purchased input. The order cycle information is then preceded and followed by enhanced information which improves the quality of the decision and the use of the delivered input.

Research has recognized that early implementations of IT for information exchange in the supply chain were oriented toward transactional efficiency (Narasimhan and Kim 2001; Williams et al. 1997). These studies acknowledge that the use of information exchange goes beyond supporting the foundational processes of the support activities in the supply chain. Specifically, IT can be used to affect the primary activities of the value creation which include: operations, inbound logistics, outbound logistics, marketing, sales, and service functions (Porter 1980). As firms look to implement just-in-time (JIT) and other strategic programs with their suppliers, key information is exchanged in order to synchronize interfirm processes (Bardi et al. 1994). Through the exchange of enhanced information, firms are able to integrate similar functions, consolidate redundant functions, and eliminate unnecessary activities thus improving their performance beyond low cost transactional processing. Thus,

Hypothesis 3: The ratio of enhanced to transactional information exchange volume is negatively associated with relationship termination.

The three proposed hypotheses are summarized in Figure 4.1. Hypothesis 1 and Hypothesis 2 identify u-shaped relationships between the information exchange characteristics and relationship termination. Hypothesis 3 proposes a negative relationship between the ratio of enhanced to transactional information exchange and relationship termination.

Figure 4.1 Information Exchange Hypotheses



4.3 Research Methodology

The goal of this study is to explore the relationship between information exchange and relationship termination in a business-to-business dyad. Using the electronically-mediated trading partner network detailed in Chapter 3, specific measures of information exchange are defined to support hypothesis testing to associate dyadic information exchange characteristics with relationship termination. Since previous research has not addressed information exchange characteristics and supply chain performance at this level of granularity, a multi-level analysis is provided. First, a logistic regression model is developed to support an event history analysis using the information exchange characteristics as independent variables and relationship termination as a dichotomous dependent variable. Second, an alternative event history analysis is developed using the Cox Proportional Hazards Model.

4.3.1 Data

The data provided for this study support multiple levels of analysis. Analysis of trading partner relationship termination is best understood through longitudinal data at the dyadic relationship level. The dataset includes monthly observations of information exchange between each of the thirty-nine technology champion firms and their electronically-mediated trading partners. Each dyadic relationship is characterized by its information exchange and its potential termination. Using multiple analysis tools, this portion of the dissertation will evaluate trading partner relationship termination at a dyadic level.

A key aspect of event history analysis is identifying the group of study participants that are at risk of the hazard occurring during a given period. Trading partner relationships that are at risk during a given time period are referred to as the "risk set" (Allison 1985). In a supply chain context, trading partner relationships that are terminated in January are no longer at risk in February. At the end of each period in the study, the set of study participants is reduced by the number of relationships that experience termination. Event history studies require knowledge of the number of participants that are at risk each period and the number of participants that experience the hazard (termination) each period. Event history analysis then attempts to associate explanatory variables with the variation in the period-to-period hazard occurrences.

4.3.2 Measures

Trading Partner Relationship Termination

The termination of a trading partner relationship is operationalized through the data of an electronically mediated information exchange network. Within a given period of time, the technology champion firm either transacts with the trading partner or they do not. When information ceases to be exchanged, the relationship is considered to be terminated. A binary variable is used to identify whether the relationship has been terminated. For each month, the hazard variable is coded as '0' if information is exchanged within the dyad. When the dyadic relationship ceases to exchange information, the hazard variable is coded '1' to recognize the termination of the relationship. Due to the potential seasonality of some trading partner relationships, gaps may occur in the month-to-month data. These gaps would make it appear that a dyadic relationship was terminated and then re-started one or more months later. In a supply chain context, seasonality of some relationships may create instances where a dyad does not exchange information for a month or more but the relationship itself is continuing with transactions appearing later in the study period. A supplier of winter coats may not receive orders from a specific retailer during the spring months, but as the planning for winter sales begins, information will start being exchanged and the relationship will continue. Trading partner relationships are only considered terminated if they stop transacting and do not resume transacting in a later month during the study. The termination variable is set to '1' to identify termination of a relationship only if the information exchange does not resume during the study period.

Relationship termination is identified by the absence of transactions in future periods. Since the dataset includes data for twenty-four months, there are no relationships identified as terminated in the last month of the study (month 24). Without data for the 25th month, there is no way to ascertain whether relationships continued or were terminated. This situation is common in longitudinal studies where variables are based on differences between observation periods. As a result, there is no variation in the dependent variable for the twenty-fourth month of the study and those observations are all dropped prior to estimating the model.

Transactional Information Exchange Volume

The volume of transactional information exchange is measured as a count variable (in millions). Information is identified as transactional based on the categorization of EDI transaction types described in Chapter 2 and specifically listed in Appendix B. Each

EDI transaction type is identified as containing either *transactional information* or *enhanced information*. EDI transactions identified as containing transactional information are aggregated by the month for each dyad. In a longitudinal analysis, the use of a cumulative measure of transactional volume is critical due the nature of termination in a supply chain context. Practitioners recognize that when a relationship is targeted for termination, the exchange of information does not stop immediately but instead decreases over time. This situation occurs either through an intentional "weaning" of the trading partner or simply because the invoices and payments from recent shipments may require additional time before all outstanding transactions are reconciled. Use of a single month measure of information exchange volume would relate the final termination event to the prior month's potentially miniscule transactional exchanges made to reconcile a relationship whose primary exchange potentially ended months earlier. To address this issue, this study uses aggregate exchange volumes from the start of the study to the final month prior to relationship termination. This treatment of information exchange as a cumulative measure allows for termination to be explained based on a full measure of information exchange characteristics rather than potentially minimal end-of-life information exchanges that would not be representative of the true characteristics of the relationship.

To capture the non-linear relationship between transactional information exchange and trading partner relationship termination, a squared variable is introduced. The study of information and knowledge often recognize an increasing or decreasing effect at higher levels of exchange which creates a non-linear relationship. In such studies, the predictor variable causing the non-linear relationship is modeled using both its calculated value and its squared value (Berman et al. 2002; Steckel et al. 2004)   For each dyadic monthly observation, the mathematical square of the cumulative transactional information volume is calculated.

Enhanced Information Exchange Volume

The volume of enhanced information exchange is measured as a count variable (in millions) and is analogous to the transactional information exchange measure described above. Based on the categorization of enhanced information described in Chapter 2 and listed in Appendix C, EDI transaction types are identified as containing either enhanced information or transactional information.   EDI transactions identified as containing enhanced information are aggregated by month and trading dyad.

To capture the non-linear relationship between the exchange of enhanced information and trading partner relationship termination, a squared variable is introduced as described previously for the transactional exchange volume measure. For each dyadic monthly observation, the mathematical square of the enhanced information volume is calculated.

Transactional to Enhanced Information Exchange Ratio

To measure the relationship between the exchange of enhanced information and transactional information, a simple ratio is calculated. The ratio addresses the comparative effect of enhanced information to transactional information on the termination of a trading partner relationship. As shown in 4.1, the ratio is calculated by dividing the enhanced information exchange volume by the transactional information exchange volume for each unique trading dyad and month combination.

$$\mathrm{RATIO}_{ijt} = \frac{\mathrm{Enhanced\_Volume}_{ijt}}{\mathrm{Transactional\_Volume}_{ijt}} \qquad [4.1]$$

where ij represents a technology champion firm-trading partner dyad and t is a specific time period

Control Variable – Firm Dummy

The data for this analysis includes observations of thirty-nine technology champion firms. To control for the firm specific variation in the dataset, a series of dummy variables are included to identify the technology champion firms associated with each observation. The thirty-nine technology champion firms require the inclusion of an additional thirty-eight binary variables. This control variable is required in both the Logistic regression and the Cox Proportional Hazards Model to control for firm effects.

Control Variable – Month

The data includes monthly observations for each technology champion-trading partner dyad with the potential for each dyad to include up to twenty-four monthly observations. A series of dummy variables are included to identify the month of each observation and control for variation due to time. The twenty-four monthly observation periods require the use of an additional twenty-three binary month dummy variables. This variable is used in the logistic regression to control for the time effects. Control variables for time are not required in the Cox Proportional Hazards Model since the time factor is controlled using the DURATION variable.

4.3.3 Modeling Event History

The study of events and their causes have been the source of great interest in many academic fields. The event of interest is often failure in the form of death or termination with the studies addressing the potential causes of the event. In the context of supply chain relationships, the hazard encountered is that the trading partner relationship is terminated. This section examines how the hazard (termination of the supply chain relationship) is associated with the characteristics of information exchange.

In studying events, the data include the history of the event occurrence and measures of potential explanatory variables. Typically, these explanatory variables change over time creating the need to model the history as a series of longitudinal observations. Using standard regression techniques to model the data often causes unnecessary loss of information (Allison 1985). Similarly, loss of information can occur if the event of interest does not occur during the study period. If the relationship does not terminate during the study period, the length of the relationship is unknown and could be assumed to be the full length of the study, but that too would underestimate its true value in that the relationship could continue for years beyond the study. In event studies, this is referred to as censoring. Censoring is the situation where variables are measured within the range of the study period but their values are unknown prior to the study and after the study. Left-censoring refers to the unknown measures of variables prior to the study. Right-censoring refers to the unknown values after the study. Censoring also occurs when a participant in the study leaves the study prior to its completion and without experiencing the hazard event. In an electronically mediated trading partner network, firms may migrate to new technologies or change network providers which could potentially eliminate them from the study. Models that allow for censoring of data keep the observations of hazard and non-hazard relationships up to the point when the participant leaves the study thus minimizing the effects of lost data points.

In either case, the analysis of event history requires unique treatment to avoid the effects of both censored data and time varying explanatory variables. Each of these situations can be addressed using either a logistic regression or a proportional hazard model to estimate the likelihood of the event (Allison 1985). This study presents results for hypotheses tests using both methods.

Both the logistic regression and proportional hazards model estimate the likelihood of an event occurring. This allows for an additional verification of the predictive power of the models by holding back a portion of the data for post-hoc analysis of the estimated model coefficients. To facilitate this test, ten percent of the observations are not included in the data used to estimate the coefficients. This randomly generated "hold-out" sample will be used for a post-hoc analysis which is presented in the discussion of the study results.

4.3.4 Logistic Regression Modeling

A logistic regression may be used to specify how the probability of an event depends on selected explanatory variables. First, a logistic regression supports the use of a binary dependent variable to identify the event occurrence. The event of interest in this study is the termination of the trading partner relationship. Second, the model estimates the probability of the hazard (termination) occurring during a specific time period given the levels of the explanatory variables.

Using a discrete-time model, variation in the hazard in each time period is allowed by letting each intercept term (α) identify a unique time period. When using a logistic regression, these time period constants are modeled as a set of dummy variables, one for each of the observed time periods (Allison 1985). Additionally, this dataset contain observations of multiple trading partner relationships for each firm so a vector of firm dummy variables are also included in the model as shown in 4.2.

$$\log\left(P_t / \left(1 - P_t\right)\right) = \alpha_t + \beta_1 \text{TRANSACTIONAL\_VOLUME}_{t-1} + \beta_2 \text{TRANSACTIONAL\_VOLUME}^2_{t-1} + \beta_3 \text{ENHANCED\_VOLUME}_{t-1} + \beta_4 \text{ENHANCED\_VOLUME}^2_{t-1} + \beta_5 \text{RATIO}_{t-1} + \sum_{j=0}^{n} \mu_j \text{MONTH}_t + \sum_{i=0}^{n} \gamma_i \text{FIRM}_i + \varepsilon \quad [4.2]$$

where P_t is the probability of termination of a trading partner relationship

A maximum likelihood estimation is used to calculate the coefficients. The overall effect is that the data are modeled such that a unique observation is created to represent each period that a trading partner relationship is at risk. For example, trading partner relationships that terminated after four months contribute four trading partner-months of observations. Trading partner relationships that have not terminated by the end of the twenty-four months of the study are considered to be censored. Censoring in this context refers to the fact that the relationships may have terminated after the study period but that information is unknown and not within the range of study. Censored trading partner relationships then contribute the maximum twenty-four trading partner-months.

For each trading partner-month, the dependent variable is coded ‘1’ if the trading partner relationship terminated that month, otherwise it is coded zero. The information exchange characteristics then serve as explanatory variables and take on their cumulative values up through the month prior to termination. This lagging of the explanatory variables is critical in the analysis of electronically mediated information exchange. Since the dependent variable (termination) is defined as the absence of any information exchange on the network, the month in which the trading partner relationship is absent will show zero values for both the transactional and enhanced information exchange volumes. A simple lagging of one month then relates the termination in one month to the information exchange characteristics cumulative to the month prior to termination. For example, a trading partner relationship that shows no transactions in October is coded as terminated for the month of October and the information exchange characteristics are measured as cumulative up to the termination occurrence. Since the relationship had no transactions in October, the transactional and enhanced information exchange volumes are cumulative through September. The variables for the logistic regression analysis are summarized in Table 4.1.

Table 4.1 Definition of Logistic Regression Model Variables

Variable	Definition
Dependent Variable	
$TERMINATION_{it}$	1 if terminated in that month, 0 otherwise
Independent Variables	
$TRANSACTIONAL\_VOLUME_{ijt}$	Cumulative volume of transactional information exchange between a trading partner and the technology champion firm
$TRANSACTIONAL\_VOLUME^2_{ijt}$	The mathematical square of the cumulative volume of transactional information exchange between a trading partner and the technology champion firm
$ENHANCED\_VOLUME_{ijt}$	Cumulative volume of enhanced information exchange between a trading partner and the technology champion firm
$ENHANCED\_VOLUME^2_{ijt}$	The mathematical square of the volume of enhanced information exchange between a trading partner and the technology champion firm
$RATIO_{ij}$	The ratio of cumulative enhanced information exchange volume to the cumulative transactional information exchange volume between a trading partner and the technology champion firm
$MONTH_t$	A series of binary dummy variables to identify the month of observation
$FIRM_i$	A series of binary dummy variables to identify the technology champion firm

As noted by Allison (1985), the logistic regression procedure adequately handles both the censoring and time-varying explanatory variable issues that can be problematic in estimating the probability of a hazard occurring. Censoring is addressed in this study by including trading partner relationship observations for all periods in which their termination was at risk. Variances in the explanatory variables in each period are captured by including each trading partner-month combination as a separate observation and including a series of dummy variables to identify the month.

This application of a logistic regression is specifically adapted to account for changes in the hazard rate over time. By including a set of dummy variables for the time periods, the intercept is adapted for each discrete time (Allison 1985). This specification supports the inclusion of time-varying explanatory variables which recognize that the probability of a hazard occurring is explained through the cumulative exchange of information within a relationship while controlling for the effects of time.

4.3.5 Cox Proportional Hazards Model

An alternative method to model event history is the Cox Proportional Hazards regression analysis. This technique addresses the occurrence or nonoccurrence of an event and its timing. The Cox Proportional Hazards Model (hereafter simply called the hazards model) has been used in empirical research to study the likelihood of market leader dethronement (Ferrier et al. 1999), manufacturing firm survival in the UK (Disney et al. 2003), and the likelihood of a customer purchasing additional financial products given demographic factors (Thomas et al. 2005).

In this study, the event of interest is the termination of the trading partner relationship. The hazards model is one of a series of methods to estimate hazard rates but is often preferred by researchers because it efficiently estimates the model even in studies with large numbers of observations and censored observations (Ferrier et al. 1999; Tuma and Hannan 1984). As discussed previously, observations are considered censored when the event of interest occurred either before the study began or after the study period ended. Censoring of observations can be a concern in the study of supply chain relationships where many of the trading partner relationships do not experience termination during the study period. The hazards model uses each trading partner-month observation since the trading partner relationship was at risk during each month of the study regardless of whether they experienced the hazard event or not.

Two critical inputs to the hazards model are whether the relationship terminated and how long the relationship lasted. The dependent variable of the model is the dichotomous measure of relationship termination described earlier for the logistic regression model. TERMINATION is a binary measure of relationship termination and is set to '1' if the relationship terminated during the month. DURATION is a count of the number of months that the relationship existed since the beginning of the study period. The variable DURATION is entered as the time function in the model (α). The remaining explanatory variables are as described previously and are summarized in Table 4.2.

Table 4.2 Definition of Cox Proportional Hazards Model Variables

Variable	Definition
Dependent Variable	
$TERMINATION_{ijt}$	1 if terminated, 0 otherwise
Time Function Variable	
$DURATION_{ijt}$	Number of months the trading partner relationship has existed since the beginning of the study period
Independent Variables	
$TRANSACTIONAL\_VOLUME_{ijt}$	Cumulative volume of transactional information exchange between a trading partner and the technology champion firm
$TRANSACTIONAL\_VOLUME^2_{ijt}$	The mathematical square of the cumulative volume of transactional information exchange between a trading partner and the technology champion firm
$ENHANCED\_VOLUME_{ijt}$	Cumulative volume of enhanced information exchange between a trading partner and the technology champion firm
$ENHANCED\_VOLUME^2_{ijt}$	The mathematical square of the volume of enhanced information exchange between a trading partner and the technology champion firm
$RATIO_{ijt}$	The ratio of cumulative enhanced information exchange volume to the cumulative transactional information exchange volume between a trading partner and the technology champion firm
$FIRM_i$	A series of binary dummy variables to identify the technology champion firm

The only assumption of the Cox model is that the hazard is proportional in that for any two individual observations, at any point in time the ratio of their hazard is a constant. Specifically, for any point in time (t), $h_i(t)/ h_j(t) = c$ where i and j refer to distinct trading partners and c is the constant which depends on the explanatory variables but not on time. Proportionality is tested using the scaled Schoenfeld residuals of the covariates on functions of time and a visual observation of the plotted residuals. A non-zero slope is an indication of a violation of the proportionality assumption (Allison 1985).

$$\begin{aligned}(\log)\mathrm{TERMINATION}_{ijt} &= \alpha_{(t-1)} + \beta_1\mathrm{TRANSACTION\_VOLUME}_{(t-1)} + \\ &\beta_2\mathrm{TRANSACTION\_VOLUME}^2_{(t-1)} + \beta_3\mathrm{ENHANCED\_VOLUME}_{(t-1)} + \\ &\beta_4\mathrm{ENHANCED\_VOLUME}^2_{(t-1)} + \beta_5\mathrm{RATIO}_{(t-1)} + \sum_{i=0}^{n}\gamma_i\mathrm{FIRM}_i + \varepsilon \qquad [4.3]\end{aligned}$$

where i is the technology champion firm, j is the trading partner, and t is the month

4.4 Results

This study seeks to expand the understanding of how relationship termination varies according to information exchange practices. Extending the strategic management literature's use of relationship survival as a key measure of relational performance (Dyer and Singh 1998), the information exchange matrix (Figure 2.2) provides a framework to associate information exchange practices with trading partner relationship performance in the form of relationship termination.

4.4.1 Descriptive Statistics

The dataset used for this analysis includes observations of the information exchange transactions for thirty-nine technology champion firms and their electronically-mediated trading partner relationships. These data capture EDI-based electronic document exchanges over a twenty-four month period beginning January 2004 and ending December 2005. Descriptive statistics on the overall dataset are included in Table 4.3.

Table 4.3 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
TERMINATION	255,076	0.0252	0.1567	0	1.00
TRANSACTIONAL_VOLUME	255,076	0.0107	0.0802	0	10.56
TRANSACTIONAL_VOLUME^2	255,076	0.0065	0.4903	0	111.54
ENHANCED_VOLUME	255,076	0.0033	0.0315	0	3.16
ENHANCED_VOLUME^2	255,076	0.0010	0.0536	0	9.98
ENHANCED-TRANSACTIONAL_RATIO	255,076	12.9318	942.7700	0	283,562.50

Monthly information exchange within each technology champion–trading partner dyad results in a large number of observations on which to test the hypotheses. These 237,021 observations are used in both the logistic and Cox Proportional Hazard models. The measures of information exchange described in Chapter 2 and developed into specific measures for the termination models. Transactional volume is measured cumulatively up to the observation month and varies between zero and eleven million document exchanges. The mean of cumulative transactional volume is approximately eleven thousand with a relatively large standard deviation of eighty-three thousand. This indicates that the dyads included in this dataset vary greatly in the amount of transactional information exchanged.

Similarly, the measure of cumulative enhanced information exchange varies across the observed dyads. The cumulative volume of enhanced information exchange ranges from zero to approximately three million documents exchanged. The mean is approximately three thousand which is relatively low due to the fact that many dyads have an observed value of zero enhanced documents exchanged indicating that they do not exchange information beyond the transactional information.

The measure of the ratio of enhanced to transactional information exchange is affected by the variation in both the cumulative transactional and enhanced measures. The mean ratio is approximately thirteen with many dyads reporting a ratio of zero resulting from not exchanging any enhanced information documents. The mean of thirteen indicates an average ratio of thirteen enhanced documents to every transactional document. The ratio measure ranges from zero to 283,563 indicating great variation in the ratio across the dyads.

The pairwise correlations provided in Table 4.4 indicate a negative and statistically significant relationship between both the transactional volume and enhanced volume measures with relationship termination. In interpreting the relationship, it is important to remember that termination is coded as ‘1’ if the relationship is terminated and ‘0’ if the relationship is not terminated. These negative correlations indicate that at higher levels of exchange volume, the trading partner relationships are not terminated.

Table 4.4 Pairwise Correlations

	TRANSACTIONAL _VOLUME	TRANSACTIONAL _VOLUME^2	ENHANCED _VOLUME	ENHANCED _VOLUME^2	ENHANCED-TRANSACTIONAL_ RATIO
TRANSACTIONAL_VOLUME	1				
	255,076				
TRANSACTIONAL_VOLUME^2	***0.7651***	1			
	0.0000				
	255,076	255,076			
ENHANCED VOLUME	***0.1854***	***0.0159***	1		
	0.0000	***0.0000***			
	255,076	***255,076***	255,076		
ENHANCED_VOLUME^2	***0.0522***	***0.0053***	***0.8162***	1	
	0.0000	***0.0080***	***0.0000***		
	255,076	***255,076***	***255,076***	255,076	
ENHANCED-TRANSACTIONAL_RATIO	-0.0018	-0.0002	***0.0867***	***0.0346***	1
	0.7087	0.9268	***0.0000***	***0.0000***	
	255,076	255,076	***255,076***	***255,076***	255,076

Statistically significant correlations are highlighted in bold and italics

As expected, the linear and non-linear (squared) measures show a positive and statistically significant correlation for both the transactional and enhanced measures. This is not unusual in models that use squared measures for the testing of non-linear relationship. A positive and statistically significant relationship also is identified between the ratio measure (ENHANCED-TRANSACTIONAL_RATIO) and both the linear enhanced information exchange measure (ENHANCED_INFORMATION_VOLUME) and the non-linear enhanced information exchange measure (ENHANCED_INFORMATION_VOLUME^2).

The pairwise correlations provide further support for the distinct nature of the transactional and enhanced dimensions of information exchange. Transactional information exchange volume (TRANSACTIONAL_VOLUME) and enhanced information exchange volume (ENHANCED_VOLUME) are positively and statistically-significantly correlated at 18%. This positive relationship suggests that the levels of each dimension move in the same direction. However, their relatively low level of correlation suggests that they can distinctively measure two unique types of information exchange.

4.4.2 Logistic Regression Results

Results for the explanatory variables of the logistic regression model are provided in Table 4.5. The model fit is statistically significant based on the Likelihood Ratio (LR) Chi-Square test statistic. Although logistic regression does not have an equivalent to the R-squared that is found in ordinary least squares (OLS) regression, the McFadden pseudo R-squared is a provided as an indicator of the explanatory power of the model. The pseudo R-square reported for this model is 10.01%. Full results including the coefficient estimates of the control variables are included in Appendix D.

The estimated coefficients of the transactional information exchange and transactional information exchange squared variables are used to test Hypothesis 1. A negative estimated coefficient for the transactional information exchange volume variable (TRANSACTIONAL_VOLUME) indicates a decrease in the likelihood of termination with each increase in transactional information exchange volume. A negative coefficient for the squared transactional information exchange variable (TRANSACTIONAL_VOLUME^2) indicates the non-linear u-shaped relationship that is hypothesized. The negative coefficient for the non-linear term specifies that at higher levels of the transactional exchange volume, the likelihood of termination actually increases. The results support Hypothesis 1.

Table 4.5 Logistic Regression Results

TERMINATION	Coef. (Std Err)	P>| t |	sig	Hypotheses Testing
TRANSACTIONAL_VOLUME	-6.2809 (0.7646)	0.000	**	H1: Supported
TRANSACTIONAL_VOLUME^2	0.6102 (0.0764)	0.000	**	
ENHANCED_VOLUME	-10.2760 (2.1512)	0.000	**	H2: Supported
ENHANCED_VOLUME^2	3.2679 (0.8111)	0.000	**	
ENHANCED-TRANSACTIONAL_RATIO	4.41E-06 (0.00002)	0.824	ns	H3: Not Supported
$\sum_i \mu_t$ (technology champion dummy variables)	•	•	•	
$\sum_t \phi_t$ (month dummy variables)	•	•	•	
constant	-3.9163 (0.1402)	0.000	**	
observations	255,076			
LR chi2	5,684.44			
Prob > chi2	0.0000			
Pseudo R2	0.0948			
Log Likelihood	-27,150.29			

**<.01 *<.05 +<.1 significance level

The estimated coefficients of the enhanced information exchange and enhanced information exchange squared variables are used to test Hypothesis 2. As discussed for Hypothesis 1, negative estimated coefficient for the linear variable (ENHANCED_VOLUME) indicates a decrease in the likelihood of termination with each increase in enhanced information exchange volume. A negative coefficient for the squared enhanced information exchange variable (ENHANCED_VOLUME^2) indicates the non-linear u-shaped relationship that is hypothesized. The negative coefficient for the non-linear variable specifies that at higher levels of the enhanced information exchange volume, the likelihood of termination increases. The results support Hypothesis 2.

Coefficient estimates for the ratio measure (ENHANCED-TRANSACTIONAL_RATIO) are not statistically significant. Although the estimated coefficient is positive, the results do not ensure that the estimate is statistically significantly different from zero. The results do not support Hypothesis 3.

4.4.3 Logistic Regression Results – Stratified Dataset

Recognizing that the technology champion firms represent multiple locations in the supply chain, an additional analysis is conducted by stratifying the dataset. Each of the technology champion firms are identified as a manufacturing, wholesaling, or retailing firm based on their 4-digit standard industrial classification (SIC) code. The dataset is stratified using the three groups and additional coefficient estimates are calculated based on the grouped observations. Results are provided in Table 4.6.

Table 4.6 Logistic Regression Results: Stratified by Echelon

TERMINATION	Manufacturer Coef. (Std Err)	P>| t |	sig	Wholesaler Coef. (Std Err)	P>| t |	sig	Retailer Coef. (Std Err)	P>| t |	sig
TRANSACTIONAL_VOLUME	-5.7153 (2.2169)	0.010	*	-23.0539 (4.8015)	0.000	**	-10.5603 (1.2327)	0.000	**
TRANSACTIONAL_VOLUME^2	6.8415 (2.3809)	0.004	**	2.1515 (0.5459)	0.000	**	3.4942 (0.4076)	0.000	**
ENHANCED_VOLUME	-6.8762 (3.7239)	0.065	*	-5.4869 (4.3961)	0.212	ns	-25.0600 (5.4516)	0.000	**
ENHANCED_VOLUME^2	10.2529 (12.5015)	0.412	ns	1.6330 (1.7376)	0.347	ns	15.5237 (3.1330)	0.000	**
ENHANCED-TRANSACTIONAL_RATIO	-2.96E-04 (0.0005)	0.580	ns	1.72e-05 (1.44e-05)	0.233	ns	4.14E-05 (0.0003)	0.885	ns
$\sum_i \mu_i$ (technology champion dummy variables)	.	.	.	.	.	.	.	.	.
$\sum_t \phi_t$ (month dummy variables)	.	.	.	.	.	.	.	.	.
constant	-2.0442 (0.1416)	0.000	**	-2.9665 (0.2050)	0.000	**	-2.2066 (0.1547)	0.000	**
observations	51,420			43,321			160,335		
LR chi2	3,169.00			902.26			3,523.42		
Prob > chi2	0.0000			0.0000			0.0000		
Pseudo R2	0.2468			0.1265			0.0886		
Log Likelihood	-4,851.56			-3,114.46			-18,130.01		

**<.01 *<.05 +<.1 significance level

All three stratified models provide a good statistical fit of the data based on the Likelihood Ratio (LR) Chi-Square test statistic. The McFadden pseudo R-squared statistics vary by supply chain echelon. Manufacturers have the highest R-squared estimate of 24.68%, wholesalers have an R-squared of 12.65%, and retailers report a R-squared of 8.86%. The statistical results relative to the testing of Hypotheses 1 and 2 vary across echelon groups. Consistent with results for the full dataset, the echelon-based coefficient estimates do not show support for Hypothesis 3.

Coefficient estimates from each of the three echelon groups show support for the u-shaped relationship between the exchange volume of transactional information and relationship termination. The negative coefficient estimates for transactional exchange volume (TRANSACTIONAL_VOLUME) and positive coefficient for the non-linear term (TRANSACTIONAL_VOLUME^2) are consistent with the full dataset results provided in Table 4.5.

Echelon results vary for Hypothesis 2. The manufacturing echelon does not show support for Hypothesis 2. These results are shown in column 2 of Table 4.6. The coefficient for the enhanced information exchange volume measure (ENHANCED_VOLUME) is negative and statistically significant. This result indicates a negative relationship between the volume of enhanced information exchange and relationship termination at lower levels of volume, however, the non-linear measure (ENHANCED_VOLUME^2) is not statistically significant for manufacturers. The u-shaped relationship is not supported by the combined coefficient estimates so Hypothesis 2 is not supported for the manufacturing echelon.

Column 3 of Table 4.6 reports the coefficient estimates for dyadic relationships that include wholesalers as the technology champion firm. The coefficient estimates for Hypothesis 2 are not statistically significant. As a result the u-shaped relationship hypothesized for the enhanced information exchange volume is not supported in the wholesale echelon.

Column 4 in Table 4.6 reports the coefficient estimates for dyadic relationship that include retailers as the technology champion firm. The coefficient for the enhanced information exchange volume (ENHANCED_VOLUME) is negative and statistically significant. The coefficient for the non-linear measure (ENHANCED_VOLUME^2) is positive and statistically significant which supports the u-shaped relationship specified in Hypothesis 2.

4.4.4 Cox Proportional Hazards Model Results

The output of the Cox Proportional Hazards Model are consistent with the results of the logistic regression. The estimated coefficients, standard errors, statistical significance, and model statistics are presented in Table 4.7. The model fit is statistically significant based on the Likelihood Ratio (LR) Chi-Square test statistic.

Table 4.7 Cox Proportional Hazards Model Results

TERMINATION	**Coef. (Std Err)**	**P>| t |**	**sig**	**Hypotheses Testing**
TRANSACTIONAL_VOLUME	-9.7162 (0.8996)	0.000	**	H1: Supported
TRANSACTIONAL_VOLUME^2	0.9230 (0.0877)	0.000	**	
ENHANCED_VOLUME	-17.5925 (2.5864)	0.000	**	H2: Supported
ENHANCED_VOLUME^2	5.5218 (0.9024)	0.000	**	
ENHANCED-TRANSACTIONAL_RATIO	8.43E-06 (0.00002)	0.651	ns	H3: Not Supported
$\sum_i \mu_i$ (technology champion dummy variables)	▪	▪	▪	
observations	255,076			
LR chi2	5,027.21			
Prob > chi2	0.0000			
Log Likelihood	-69,576.74			

**<.01 *<.05 +<.1 significance level

The estimated coefficients for transactional information exchange volume show support for Hypothesis 1. The negative and statistically significant coefficient for the linear transactional information exchange volume measure (TRANSACTIONAL_VOLUME) combined with the positive and statistically significant coefficient for the non-linear measure (TRANSACTIONAL_VOLUME^2) support the hypothesized u-shaped relationship. The combination of a negative linear term and a positive non-linear term indicate that at lower levels of transactional information exchange, increases in the volume of information exchange is associated with a decrease the likelihood of relationship termination. At higher levels of transactional information exchange, the effect of additional transactional information exchange is associated with an increased likelihood of relationship termination.

The coefficient estimates provided by the model support the u-shaped relationship specified by Hypothesis 2. The results show a negative and statistically significant coefficient for the linear measure of enhanced information exchange (ENHANCED_VOLUME) combined with a positive and statistically significant coefficient for the non-linear measure (ENHANCED_VOLUME^2). The resulting u-shaped function supports Hypothesis 2.

Similar to the results for the logistic regression, the results do not support Hypothesis 3. The coefficient estimate for the ratio measure (ENHANCED-TRANSATIONAL_RATIO) is not statistically significant. Full results including the coefficient estimates for the control variables are reported in Appendix E.

4.4.5 Cox Proportional Hazards Model Results – Stratified Dataset

Consistent with the procedure used to test the logistic regression model, an additional analysis provided to test the model using a stratified dataset. The observations are grouped based on the technology champion firm that participated in the observed dyad. The Cox Proportional Hazards Model is then used to analyze the observations separately for manufacturers, wholesalers, and retailers. The results of the analysis are provided in Table 4.8.

Table 4.8 Cox Proportional Hazards Model Results: Stratified By Echelon

TERMINATION	Manufacturer Coef. (Std Err)	P>|t|	sig	Wholesaler Coef. (Std Err)	P>|t|	sig	Retailer Coef. (Std Err)	P>|t|	sig
TRANSACTIONAL_VOLUME	-7.2445 (2.2283)	0.001	*	-34.7517 (5.4582)	0.000	**	-15.0735 (1.4312)	0.000	**
TRANSACTIONAL_VOLUME^2	7.2641 (2.1074)	0.001	*	3.2472 (0.5900)	0.000	**	4.5713 (0.4082)	0.000	**
ENHANCED_VOLUME	-9.0192 (3.4302)	0.009	*	-8.7122 (5.2078)	0.094	+	-51.6863 (7.4789)	0.000	**
ENHANCED_VOLUME^2	16.2170 (9.8837)	0.101	ns	2.6181 (1.8341)	0.153	ns	30.8093 (4.1358)	0.000	**
ENHANCED-TRANSACTIONAL_RATIO	-3.77E-04 (0.000531	0.477	ns	2.33E-05 (1.49E-05)	0.119	ns	1.67E-04 (0.0003)	0.603	ns
$\sum_i \mu_i$ (technology champion dummy variables)	.	.	.	.	.	.	.	.	.
observations	51,420			43,321			160,335		
LR chi2	2,635.90			328.78			2,548.56		
Prob > chi2	0.0000			0.0000			0.0000		
Log Likelihood	-11,757.96			-6,419.96			45,616.05		

**<.01 *<.05 +<.1 significance level

In all three analyses, the model fit is statistically significant based on the Likelihood Ratio (LR) Chi-Square test statistic. Consistent with the results of the logistic regression, stratified logistic regress, and Cox Proportional Hazards Model, the stratified analysis shows support for Hypothesis 1 for all three echelons. Hypothesis 1 specified a u-shaped association between the volume of transactional information exchange and relationship termination. Similar to the prior test, the stratified Cox Proportional Hazards model does not show support for Hypothesis 3. Hypothesis 3 specified a positive association between the ratio of enhanced information exchange volume to transactional information exchange volume and relationship termination.

Results for Hypothesis 2 vary between the three supply chain echelons. For the manufacturing and retail echelons, the results mirror the results of the stratified logistic regression. The coefficient for the linear term (ENHANCED_VOLUME) is negative and statistically significant and the coefficient for the non-linear term (ENHANCED_VOLUME^2) is positive and statistically significant. The results then support the u-shaped relationship posed by Hypothesis 2.

Results for the wholesaler group pertaining to the testing of Hypothesis 2 are different from the results found using the logistic regression. Neither of the coefficients estimated for the enhanced information exchange volume are statistically significant. Hypothesis 2 is not supported in the wholesaler echelon. Full results for the stratified output are provided in Appendix E.

4.5 Discussion

Together, these two statistical tests provide consistent support for the association of information exchange characteristics and relationship termination in this electronically-mediated exchange network. The additional stratified tests of each model provide insight into the possible differences between the effects of information exchange at different locations in the supply chain.

Strong support is shown for Hypothesis 1 at both the full network and echelon levels of analysis. A u-shaped relationship is found associating the volume of transactional information exchange and relationship termination. Dyadic relationships in this electronically-mediated network show a negative association between increasing levels of transactional exchange volume and relationship termination. At higher volumes of transactional exchange there is a diminishing return reflected by the non-linear or u-shaped curve. These results compliment two divergent literature streams. Researchers have noted that moving away from discrete market transactions to recurring relational exchanges provides advantages to both buyers and sellers (Kalwani and Narayandas 1995; Webster 1992). Since this study uses the exchange volume of order cycle information as the measure of transactional exchange volume, high levels of transactional information exchange may be indicative of these recurring relational exchanges. Trading dyads in this study showed a mean level of transactional information exchange volume in excess of 11,000 documents and are participating in an electronically-mediated exchange network. This volume and the investment in resources to initiate an EDI relationship would suggest that these firms have a long-term orientation that characterizes a move away from discrete market exchange. However, it is interesting that at higher levels of transactional information exchange, the likelihood of relationship termination increases. TCT would support that firms may internalize transactions when the risk of opportunism is high or the economies of scale increase such that internal production becomes an efficient alternative (Williamson 1975). Alternatively, dyads may exit the network when transaction volumes become so great that it become economical to create custom IOS applications.

Both models of the full network provided strong support for Hypothesis 2. The volume of enhanced information exchange shows a u-shaped association with relationship termination. In the Campbell’s Soup Company example, exchanging additional demand and inventory information allowed them to integrate the replenishment process with their retailers (Lee et al. 1999). The diminishing return on increasing levels of enhanced information exchange may be the result of many factors. From an information overload perspective, high levels of enhanced information exchange may create noise in the relationship that does not add value or may even increase costs due to the resources needed to filter out unnecessary information (Steckel et al. 2004). An alternative explanation for increased relationship termination at higher volumes of enhanced information exchange may be related to the dependency and proprietary knowledge that is created when interfirm processes are developed. These embedded processes may create a situation of small numbers bargaining where it is difficult for rival firms to compete for the buyer's business (Williamson 1975). In the Campbell's Soup Company example noted above, retailers could become dependent on the inventory management services provided by Campbell's which may increase their cost of switching to a new soup supplier (Pfeffer and Salancik 1978). Additionally, Campbell's gains access to proprietary customer information in order to manage the inventory processes (Subramani 2004). This information may not be available to rival firms and creates a competitive advantage that may limit the actions of rival firms. In either case, the relationship may suffer from a lack of competition resulting in sub-optimal performance and subsequent relationship termination.

Additional measures may enhance this type of analysis. Given the variability of results at the level of the firm, individual-firm level strategies that are not visible through the electronically-mediated network may be confounding the analysis. The current models and measures compare firms based on the levels of all firms. When firm level effects created confounding results in empirical strategic management research, the measures were adjusted to focus on their relation to firm characteristics (Woodward 1965). This type of analysis would then consider how the characteristics of one trading partner relationship vary compared to the norm of how trading partner relationships are managed by the technology champion firm. When firms have standard practices of exchange with their trading partners, relationships that deviate significantly from that norm are more likely to experience termination. Trading partner relationships that are characterized as being further from the firm level norm in either direction would be expected to be at greater risk. This additional alternative measure would focus on within firm differences to compliment the current analysis.

This study focuses on the volume and type of information exchanged between firms in an electronic network. Additional measures beyond volume may be included. Such measures might include the direction of information flow, the asymmetry of the directional flow, and the variability of exchange. Some of these measures are used to develop variables in Chapter 5 where information exchange characteristics are associated with a focal firm's performance.

4.5.1 Evaluation of the Non-linear Specification

The statistically significant coefficients for the non-linear terms indicate that at some level of volume, the slope begins to flatten and potentially becomes positive. Managerially it is important to understand at what volume of information exchange this phenomenon occurs. Calculating the first derivative of the function identifies where the slope becomes zero when all other variables are held constant. For the full model, the slope of the transactional information exchange volume becomes zero at 5.15 million transactions per month. This is relatively large considering that the mean value for monthly transactional information exchange is 0.01 million. The slope of the enhanced information exchange volume curve becomes zero at 1.57 million transactions which is still relatively large given that the mean value for monthly enhanced information exchange is 0.003 million. These relatively large values suggest that although there is a diminishing return on increases to exchange volumes, the detrimental effects on relationship termination occur at such high levels that very few relationships are affected.

The initial hypotheses and models put forth in this study include a non-linear relationship for both the transactional and enhance dimensions of information exchange. As shown in Tables 4.5 and 4.7, these measures are statistically significant for the testing of the full dataset. Additionally, both models show a good statistical fit of the data. As an alternative specification, the coefficients are estimated and model statistics generated using only the linear terms. Results for the logistic regression are provided in Table 4.9.

Table 4.9 Logistic Regression Results for Linear Model

TERMINATION	**Coef. (Std Err)**	**P>| t |**	**sig**
TRANSACTIONAL_VOLUME	-5.2227 (0.6905)	0.000	**
ENHANCED_VOLUME	-9.9763 (2.0502)	0.000	**
ENHANCED-TRANSACTIONAL_RATIO	4.58E-06 (0.00002)	0.818	ns
$\sum_i \mu_t$ (technology champion dummy variables)	•	•	•
$\sum_t \phi_t$ (month dummy variables)	•	•	•
constant	-19.8632 (0.1656)	0.000	**
observations	255,076		
LR chi2	5,665.84		
Prob > chi2	0.0000		
Pseudo R2	0.0945		
Log Likelihood	-27,159.59		

**<.01 *<.05 +<.1 significance level

As shown in Table 4.9, the logistic regression results using a linear model provides results consistent with the fully specified model. Both the transactional information exchange volume measure (TRANSACTIONAL_VOLUME) and the enhanced information exchange volume measure (ENHANCED_VOLUME) provide negative coefficients that are statistically significant. The coefficient for the ratio of enhanced to transactional information exchange volume (ENHANCED-TRANSACTIONAL_RATIO) is not statistically significant. The overall model fit is statistically significant and provides a pseudo r-square measure that is greater than nine percent.

The Cox Proportional Hazards model is also validated using a linear specification. Table 4.10 provides a summary of the coefficient estimates and model fit statistics.

Table 4.10 Hazards Model Results for Linear Model

TERMINATION	**Coef. (Std Err)**	**P>| t |**	**sig**
TRANSACTIONAL_VOLUME	-8.1876 (0.7762)	0.000	**
ENHANCED_VOLUME	-27.5571 (3.0222)	0.000	**
ENHANCED-TRANSACTIONAL_RATIO	0.00002 (0.00002)	0.309	ns
$\sum_i \mu_i$ (technology champion dummy variables)	•	•	•
observations	255,076		
LR chi2	5,049.95		
Prob > chi2	0.0000		
Log Likelihood	-69,565.37		

**<.01 *<.05 +<.1 significance level

As shown in Table 4.11, the hazard model results using a linear model provide results consistent with the fully specified model. Both the transactional information exchange volume measure (TRANSACTIONAL_VOLUME) and the enhanced information exchange volume measure (ENHANCED_VOLUME) provide negative coefficients that are statistically significant. The coefficient for the ratio of enhanced to transactional information exchange volume (ENHANCED-TRANSACTIONAL_RATIO) is not statistically significant. The overall model fit is statistically significant.

An additional post-hoc analysis is conducted to test the interaction of transactional and enhanced information exchange. Table 4.11 provides the regression results for the logistic model.

Table 4.11 Logistic Regression of Interaction Model

TERMINATION	Full Model Coef. (Std Err)	P>| t |	sig
TRANSACTIONAL_VOLUME	-5.2742 (0.6569)	0.000	**
ENHANCED_VOLUME	-17.1490 (2.5326)	0.000	**
TRANSACTIONAL_X_ENHANCED	23.5358 (2.9978)	0.000	**
ENHANCED-TRANSACTIONAL_RATIO	0.00001 (0.00002)	0.56	ns
$\sum_i \mu_t$ (technology champion dummy variables)	.	.	.
$\sum_t \phi_t$ (month dummy variables)	.	.	.
constant	-3.9139 (0.1402)	0.000	**
observations	255,076		
LR chi2	5,704.27		
Prob > chi2	0.0000		
Pseudo R2	0.0951		
Log Likelihood	-27,140.37		

**<.01 *<.05 +<.1 significance level

These results identify a positive and statistically significant relationship for the interaction variable. Neither the statistical fit of the model nor the explanatory power of the model (pseudo r-square) is improved by the inclusion of the interaction variable. The statistically significant and positive coefficient suggests that a combined effect of transactional and enhanced information exchange is positively associated with relationship termination. Similar results are found when the interaction variable is modeled in the Cox Proportional Hazards Model. This finding may be explained by the fact that relationships with high levels of both enhanced and transaction volume may be ripe for opportunistic behavior (either by the technology champion firm or its trading partner). This opportunism may result in relationship termination.

4.5.2 Model Predictive Power

An additional test of a logistic regression model is how well it predicts (log-odds) the outcomes for each observation. There are two approaches to this verification. The first is a traditional classification table where the estimated coefficients are used to predict the already known outcomes. As shown in Table 4.12, the model accurately predicts nearly 99% of the relationships that are not terminated (TERMINATION=0) and less than one percent of the relationships that are terminated (TERMINATION=1). The overall predictive accuracy of the model is 97.36%. Table 4.12 shows that of the 223,752 observations that were not terminated, the model correctly predicts 223,484 of the observations. The model also correctly predicts eleven of the 5,796 observations that ended in termination. Overall, the model correctly predicts the outcomes for 97.36% of the observations. The model has a higher accuracy in predicting observations that do not terminate. This is not surprising since the coefficients were estimated based on a dataset where the hazard occurred for only 3% of the observations. For comparison, a naïve model which uses no explanatory variables can be estimated based on the larger proportion of outcomes. In this case, a naïve model would be based on 97% of the observations not terminating. Since the naïve model would be correct 97% of the time, the logistic model a slightly better overall predictor (97.36%) than the naïve model.

Table 4.12 Classification Table for Estimation Sample

	TERMINATION		Percentage Correct
	1	0	
1	5,796	11	0.19%
0	223,752	223,484	99.88%
Overall Percentage			97.36%

An additional test of the logistic model can be made when a large number of observations are available. A holdout sample of the data is reserved for testing the predictive ability of the estimated coefficients. For this study, a post-hoc logistic regression estimation was made using a random sample of 90% of the observations. The estimated coefficients were then used to predict the 10% holdout sample. Table 4.13 shows resulting predictions based on the coefficients from the 90% sample. The results are generally consistent with the 90% sample. The accuracy of predicting termination is slightly lower and the accuracy for predicting observations that did not terminate is slightly higher such that the overall predictive accuracy is 0.09% higher.

Table 4.13 Classification Table for Holdout Sample

	TERMINATION		Percentage Correct
	1	0	
1	628	1	0.16%
0	24,900	24,882	99.93%
Overall Percentage			97.47%

4.5.3 Sensitivity Analysis

The hypothesized model tests the effects of volume pertaining to two dimensions of information exchange. Statistically significant negative coefficients are estimated for both dimensions which brings forth the question of whether it is better to increase the volume of the transactional information exchange or the volume of the enhanced information exchange in order to affect the greatest decrease in the likelihood of termination. To address this issue, a sensitivity analysis was conducted based on the estimated coefficients and average firm values from the dataset.

The sensitivity analysis tested an independent change of 10% for each information exchange dimension. At the average, a 10% increase in transactional information exchange volume decreases the likelihood of relationship termination by 0.032%. A 10% increase in the enhanced information exchange volume decreases the likelihood of relationship termination by 0.016%. The difference in the effect of a 10% change in each dimension is in favor of transactional information exchange by a factor of two which is consistent with the difference in the magnitude of the estimated coefficients.

4.5.4 Potential Alternate Hazard Measure

The occurrence of the hazard event used in this study is the complete termination of information exchange. While this certainly represents the most extreme detrimental relational performance, it is possible for a relationship to experience detrimental effects without complete termination of information exchange. In such a case, a technology champion firm may continue exchanging information with a trading partner but at such a reduced level that for all intents and purposes the relationship is terminated. As the hazard is currently modeled, this occurrence is not identified. An alternative operationalization of the hazard event would be to identify the relationship as terminated if it experiences a significant reduction in information exchange volume.

This alternate hazard occurrence is modeled and tested using the Cox Proportional Hazard Model for a subset of the data. Results in Table 4.14 are for Retailer E under both the original hazard classification of compete termination of information exchange and a 90% reduction in information exchange volume. The results for the complete termination hazard are presented on the left side of the table and the results for the 90% reduction hazard are presented on the right side of the table.

Table 4.14 Results of Alternate Hazard Specification

	Complete Termination			90% Reduction in Volume		
TERMINATION	Coef. (Std Err)	P>| t |	sig	Coef. (Std Err)	P>| t |	sig
TRANSACTIONAL_VOLUME	-27.2986 (11.1216)	0.014	*	-25.4915 (10.7690)	0.018	*
TRANSACTIONAL_VOLUME^2	17.1548 (7.8796)	0.029	*	15.9609 (7.7061)	0.038	*
ENHANCED_VOLUME	-133.334 (47.0514)	0.005	*	-132.8486 (46.4153)	0.004	*
ENHANCED_VOLUME^2	496.3032 (158.0812)	0.002	*	491.8573 (155.2014)	0.002	*
ENHANCED-TRANSACTIONAL_RATIO	0.0275 (0.0256)	0.282	ns	0.0274 (0.0257)	0.287	ns
observations	3,740			3,740		
LR chi2	38.69			38.86		
Prob > chi2	0.0000			0.0000		
Log Likelihood	-634.09			-643.57		

**<.01 *<.05 +<.1 significance level

Results are consistent for the testing of Hypotheses 1, 2, and 3. The alternative specification of the hazard occurrence identified two additional trading partner relationships as terminated. These two relationships were still transacting with the technology champion firm but at a significantly reduced volume.

This alternative operationalization of the hazard event captures an important phenomenon in business that is not recognized in the full termination measure. It would not be unusual for a trading partner to provide a unique product that may require the technology champion firm to maintain the relationship even though all other transactions have been diverted to alternate relationships.

4.6 Conclusion

The study provided in Chapter 4 makes several contributions. First, this study contributes to the supply chain literature by recognizing that all information is not equal. This study distinguishes between transactional information exchange and enhanced information exchanged as used to support interfirm relationships. Second, these distinct information types are specifically measured and used in an empirical analysis of their role in relational performance. Third, the empirical results give greater insight into the potential role of information exchange characteristics in relationship termination.

These two longitudinal event analyses show consistent support for two of the three hypotheses and establish a foundation for further investigation into the role of information exchange in supply chain relationships. Additionally, stratified analyses identify echelon level effects that contribute to a realization that the effects of information exchange on relationship performance may be conditional to the location of a firm within the supply chain. Chapter 5 builds on theses results and extends the research by examining this data in a panel format where information exchange characteristics and firm level performance are modeled longitudinally.

Chapter 5: Supply Chain Performance

5.1 Introduction

Having examined the data on a firm-by-firm basis in Chapter 4, this study focuses on the effects of information exchange characteristics on the performance of the technology champion firm. By considering the firm's performance over time, both performance and the characteristics of how the firm manages its portfolio of trading partners can be analyzed.

Recent research has shown that this "portfolio" approach to analyzing supply chain partners is very useful because it gives insight into how firms strategically leverage their set of trading partners instead of focusing on a specific buyer-supplier relationship. Research has recognized that not all supply chain relationships are equal but that the set of trading partner relationships is managed similar to an investment portfolio where a range of relationship structures coexist (Golicic and Mentzer 2006; Lambert et al. 1996a).

Although the literature has recognized the benefits of information exchange in supply chain relationships, it has failed to explore how a firm's leveraging of information exchange across their portfolio of trading partner relationships is associated with supply chain performance. Additionally, information exchange has often been treated as a uni-dimensional or binary measure (Croson and Donohue 2006; Whipple et al. 2002). This study addresses this gap in the literature by developing and testing hypotheses related to information exchange characteristics and the management of a firm's trading partner portfolio.

In this chapter, several key hypotheses are developed from transaction cost economics theory and applied to the burgeoning literature on supply chain portfolios. Section 5.2 presents relative theory and five hypotheses, Section 5.3 explains the research methodology, and Section 5.4 provides empirical results which are discussed in Section 5.5. Section 5.6 provides a conclusion with potential applications and directions for future research.

5.2 Development of Hypotheses

Research has recognized that trading partner interactions can vary between discrete market-like transactions and closer integrated relationships (Frohlich and Westbrook 2001; Webster 1992; Williams 1994). It is further noted that firms can signal their intention to maintain a relationship by firm resources to develop relationships with specific trading partners (Anderson and Weitz 1992; Anderson and Narus 1990). When firms invest resources in selected trading partner relationships, this investment often cannot be used for other relationships. This dedication of resources is noted for creating an environment where unique benefits accrue to that relationship. The use of firm assets in for relationship-specific investments has been shown to result in alignment of interfirm transactions such that business process specificity is created (Subramani 2004). Business process specificity means that participants in the relationship change their internal processes in order to coordinate their efforts with the partnering firm.

In practice, business process specificity takes the form of supply chain relationships where interfirm processes are reengineered to meet the needs of a specific trading relationship. At Ford's Chicago Assembly plant, the supplier that makes the upholstered ceiling panel (headline) for the car interior is now integrated to supply the entire headliner assembly. By supplying the complete assembly, the unit is delivered to the Ford assembly plant with all accessories and wiring pre-installed. Ford no longer stocks the headliner accessories for installation at the assembly plant but instead relies on their supplier to deliver the headliner assemblies ready for installation (Kerwin 2004).

From an IT perspective, the value of closeness has grown out of the vendors-to-partners thesis (Bakos and Brynjolfsson 1993). The vendors to partners thesis suggests that the use of IT in supply chains leads to closer buyer-supplier relationships. Outcomes of these closer supplier relationships include improved quality, innovation, responsiveness, trust, and information sharing (Rozenzweig et al. 2003). This strategic use of IT in the supply chain has been expanded empirically to associate the operational and strategic benefits of IT use for suppliers (Subramani 2004).

The extant literature on the impact of close versus arms-length supply chain relationships on supply chain performance shows mixed results. As described earlier in this dissertation, close relationships are characterized by a significant amount of information exchange. This information exchange allows firms to coordinate their activities possibly to improve their supply chain performance. For example, a supplier may be able to share forecast inventory information with their customer so that a customer may be able to delay purchasing materials and adopt an ordering policy that more closely resembles a “just-in-time” ordering policy. Just-in-time ordering has been shown to increase supply chain performance by increasing inventory turnover.

The transaction cost economics literature also describes the fact that close relationships are much more prone to opportunism than arms-length relationships (Williamson 1975). This may occur because the customers may not have much leverage over an important supplier. For example, a firm may only source an input product from one close supplier. If that supplier acts opportunistically, it may push some of its inventory on the customer or even refuse to fulfill a customer order because there is little leverage that would allows the customer to retaliate. In these two cases, one would expect a customer's supply chain performance to be negatively impacted. The customer would experience a decrease in inventory turnover as a result of excess inventory that is being pushed by the supplier. Inventory turnover would be adversely affected if the customer chooses to increase safety stock in order to account for likely under-fulfillment or non-fulfillment of its orders. The development and maintenance of close trading partner relationships requires firm resources such that there is additionally a cost of having close relationships (Lambert et al. 1996a). To be an effective use of scarce firm resources, the close relationship must provide subsequent benefits to offset the costs (McCutcheon and Stuart 2000). So beyond the potential for opportunism, this cost-benefit perspective further suggests that developing close relationships with all trading partners may not be in the best interest of the firm. Since there is a lack of consensus in the existing literature, two hypotheses are proposed:

Hypothesis 4: The greater use of close trading partner relationships is ***positively*** *associated with supply chain performance.*

Hypothesis 4 Alternative: The greater use of close trading partner relationships is ***negatively*** *associated with supply chain performance.*

From a strategic purchasing perspective, research has focused on the benefits of long-term orientation between a firm and its suppliers (Chen et al. 2004). Benefits accrue when a long-tem perspective fosters cooperation, reduces functional conflict, and improves decision making (Morgan and Hunt 1994). Alternatively, a short-term relationship focus squanders relationship benefits as firms expend resources to protect themselves against opportunistic actions by their supply chain partners (Ghoshal and Moran 1996).

When the portfolio of trading partners is unstable due to the continual termination of relationships and introduction of new relationships, resources are expended in setting up interfirm processes rather than reaping the benefits of the relationship. Thus,

Hypothesis 5: Greater trading partner churn is negatively associated with supply chain performance.

Firms choose whether to share information with their trading partners. The ability to withhold information from customers and suppliers has been identified as a source of power in relationships (Shapiro and Varian 1998). Conversely, the sharing of information has been associated with the development of stronger interfirm relationships (Frohlich and Westbrook 2001; Morgan and Hunt 1994). Research into the development of close relationships notes that balanced dyadic information exchange is indicative of strong relationships (Lambert et al. 1999).

In the context of electronically mediated information exchange, the flow of information is bi-directional. Each participant in the network has the opportunity to send and receive information. While transactions sent by one trading partner are always received by another trading partner, there is no assumption that each trading partner sends the same volume of information that it receives within the dyad.

A manufacturer may integrate its customer's forecasts into its production scheduling process but they may not provide their production schedules back to the customer for input into the customer's supply planning processes.

Prior studies have identified the importance of information visibility in the creation of integrated supply chain relationships (Frohlich and Westbrook 2001; Rozenzweig et al. 2003). Although the intensity of trading partner integration has been found to be positively related to business performance (Rozenzweig et al. 2003), the balance of the integration has not been fully developed and tested empirically. Similarly, the specific exchange of information has been characterized by its width, breadth, and range (Williams et al. 1998) but with little attention to the directionality of information exchange.

Prior research has recognized the detrimental effects of imbalance in the exchange of information in both the retaining of benefits by one participant (Cachon and Zhang 2006) and deterring formation of a long-term orientation in the relationship (Corsten and Kumar 2005). Thus,

Hypothesis 6: Greater asymmetry of information exchange is negatively associated with supply chain performance.

The concentration of market share is of great interest in the industrial organization (IO) literature. From an IO perspective, the concentration of market share between few market participants is an indication of low competition. The concentration of information exchange is similarly important in a supply chain context. Although firms may exchange information with each of their trading partners, the information exchange need not be equally distributed across the portfolio of trading partner relationships. Supply chain relationship literature suggests that performance is enhanced by building into the appropriate relationships while keeping others at arms-length (Lambert et al. 1996b). The trend of concentrating procurement activities with a smaller supply base has been copied from the Japanese and has been identified as a strategic procurement trend starting in the 1990s (Trent and Monczka 1998). This is an adaptation of the keiretsu strategy implemented by the Japanese whereby firms work in closely knit groups characterized by cooperation, trust, and long-term relationships (Hanna and Newman 2007). Focusing scarce firm information resources with fewer trading partner is a strategic effort to ensure that the information is used in the best interests of the firm. Thus,

Hypothesis 7: Greater information exchange concentration is positively associated with supply chain performance.

5.3 Research Methodology

5.3.1 Data

This study empirically assesses the impact of trading partner relationships on firm performance using longitudinal data. Data for the characteristics of the trading partner relationships are gathered from the electronically mediated trading network described in Chapters 3 and 4. Additional firm performance data is gathered from Standard and Poor's Compustat database. Compustat reports firm and industry level performance measures based on publicly traded firms (firms filing a 10K with the Securities and Exchange Commission) and is often used in empirical research (Gaur et al. 2005; Silverman 1999).

The unit of analysis for this study is the technology champion firm performance during each calendar quarter. Quarterly data was selected as the time period for the study because it is the smallest discrete period provided by Compustat. The information exchange network provides data on a monthly basis for each technology champion firm. In order to match the time periods, the monthly electronic network data is aggregated to the calendar quarter for years 2004 and 2005.

Additionally, during the study period some of the firms completely migrated to other networks or technologies resulting in missing observations. Missing observations were investigated with the network provider to identify their cause. This resulted in exiting firms being included in the study up to the time they began migrating off the network. The net effect is that not all firms include observations for all eight time periods.

Financial data were collected from Standard and Poor's Compustat database for the corresponding time periods (quarterly for 2004 and 2005). Additional quarterly sales measures were collected for the two years prior to the study. The additional sales data were required for calculating the sales forecast which is incorporated into a control variable which is discussed in the next section.

5.3.2 Measures

Inventory Turnover

Inventory turnover is a standard measure of asset productivity. It is calculated as a ratio of a firm's cost of goods sold to the firm's inventory value during a specific period. Inventory turnover is often used as a performance measure for empirical supply chain research (Droge and Germain 2000; Kalwani and Narayandas 1995; Lee et al. 1999; Mukhopadhyay et al. 1995; Rajagopalan and Malhotra 2001).

This study follows similar studies of firm performance by recognizing that the measuring of intermediate variables which are directly related to the process of interest is more appropriate than focusing on final performance measures such as return on investment (Lee et al. 1999). Inventory turnover has been the firm performance measure of choice in studying the business value of EDI (Mukhopadhyay et al. 1995). They found that EDI enabled coordination between a manufacturer and its suppliers resulting in a improvement of inventory turnover. Similarly, inventory turnover has been used as an intermediate performance indicator when considering the firm level effects of eCommerce capabilities (Zhu and Kraemer 2002). They found a positive relationship between a firms eCommerce capabilities and inventory turnover.

Inventory levels as a performance measure have also been used in their raw form as just the value of inventory for a period (Droge and Germain 2000). This study follows the previously cited studies which use the inventory turnover ratio since it reflects the efficiency by which the asset is used (Stevenson 2007). The inventory turnover ratio indicates how many times per period the inventory is sold, where higher ratios reflect a better use of the asset.

$$INVENTORY\_TURNOVER_{it} = \frac{COGS_{it}}{ENDING\_INVENTORY_{it}} \qquad [5.1]$$

Notably, the inventory turnover ratio is often calculated using an average measure of inventory in the denominator. Use of an absolute inventory value can be problematic since period end inventory values can be manipulated by expediting shipments or delaying receipts. This is most often an issue when yearend inventory is used to calculate the inventory efficiency for the firm. In this study, quarterly values of inventory are provided from the Compustat database to calculate inventory turnover ratios. Since quarterly values provide a more frequent assessment of inventory value they are assumed to produce adequate estimates of firm inventory efficiency.

Relationship Closeness

Research has recognized the movement of firms away from discrete market (arms-length) relationships toward what has been termed the extended enterprise where firms form ties with firms beyond their own firm boundaries (Bowersox and Daugherty 1987). This model has been tested empirically through an in-depth analysis of firms extending their connections beyond the boundaries of their firm (Edwards et al. 2001). This study found firms generally pursued one of two strategies with their supply chain relationships; traditional cost-based (arms-length) relationships or collaborative approaches. A key characteristic of the relationships in the study was the amount of information shared. Traditional relationships were noted for limited knowledge transfer and inferior comparative performance. Leading companies in the study took the collaborative approach where the exchanging of information was a standard practice.

Using perceived measures of information exchange, the strategic and operational effects have been captured (Fawcett et al. 1996). The use of information exchange was found to contribute to both operational flexibility and strategic planning. This research was expanded by specifically looking at logistics related processes whereby information connectivity was found to occupy a mediating role between a firm's logistics program and performance outcomes (Closs et al. 2005).

For the purposes of this study, a firm's use of close trading partner relationships is measured based on their information exchange characteristics. The information exchange matrix presented in Figure 2.2 characterizes the distinction between trading partner relationships based on their transactional information exchange volume and their enhanced information exchange volume.   From an information exchange matrix perspective, close trading partner relationships would be found in the II Close Relationships quadrant.

The proportion of a technology champion firm's trading partner relationships that are assigned to the II Close Relationships quadrant is used in this study as a measure of the firm's use of close trading partner relationships. This operationalization of trading partner relationship closeness is an extension of the perceived measures used in survey research (Edwards et al. 2001; Fawcett et al. 1996).

Trading Partner Churn Rate

The churn rate is a measure of the instability in the trading partner portfolio. Similar to measures of termination in Chapter 4, the trading partner churn rate is the ratio of terminated relationships to the total number of relationships with the champion firm during the period.

$$\text{CHURN\_RATE}_{it} = \frac{\text{Terminated\_Relationships}_{it}}{\text{Total\_Relationships}_{it}} \qquad [5.2]$$

Symmetry of Information Exchange

Information exchange in an electronically-mediated network can be measured directionally. From the perspective of the technology champion firm, each transaction is either sent by the champion firm or received by them. EDI transactions exchanged on the network are coded with the sending and receiving participant's mailboxes. The technology champion firm's strategy of withholding and receiving information is characterized by the balance between the volume of information transactions received and the volume of information transactions sent during the period.

As shown in Equation 5.3, the resulting ratio is a measure of the balance between information received from trading partners and information sent to the trading partners. By taking the absolute difference of the received and sent volume divided by the total volume, a measure of balance or symmetry is provided. As the value approaches "1" there is greater imbalance or asymmetry. When the value approaches zero, there is balance between the sending and receiving of information by the technology champion firm during the period.

$$ASYMMETRY_{it} = \frac{\left| Receive\_Volume_{it} - Send\_Volume_{it} \right|}{Total\_Volume_{it}} \qquad [5.3]$$

Information Exchange Concentration

Concentration measures are used in industrial organization and strategy literature to measure how market share is allocated between market participants (Collins and Preston 1969; MacDonald 1987). In these studies, the measure identified if a market is highly concentrated or highly fragmented. A fragmented market has many participating firms with relatively equal shares of the market. In a fragmented market, competition is expected to be higher. Conversely in a concentrated market, there is relatively little competition as the market is dominated by fewer large participants (Waldman and Jensen 1998). The Herfindahl-Hirschman Index (HHI) measures the market concentration by taking into account both the number of firms participating in the market and the inequality of the market shares. HHI uses the sum of the squares of the market share of all firms in the market or industry. The resulting value is multiplied by 10,000. Using this approach, HHI approaches zero for perfectly competitive markets and equals 10,000 for a monopoly.

As a descriptive measure, researchers have captured concentration as it applies to the trading partner portfolio (Hewett et al. 2002). Through use of a survey instrument they found that industrial buyers in their sample on average purchase 58.9 percent of their goods from their most important seller. Similarly, the sellers in their sample indicated that on average 45.1 percent of their sales were with one buyer. Although this measure of concentration is not as precise as the HHI, it provides a strong indication that exchange for these companies is highly concentrated. Although the role of trading partner concentration in a firm's strategy is observed, it has not been objectively measured or developed as an explanatory measure in supply chain performance.

Concentration of procurement with suppliers is addressed in marketing literature as it relates to dependency (Krapfel et al. 1991). As the percentage of exchange with a trading partner increases, it becomes more difficult to divert the business to alternate trading partners (Heide and John 1988).

Applying the HHI approach to the information exchange practices of the technology champion firm provides a measure of whether information is being exchanged equally with all trading partners in the firm's portfolio (fragmented) or if information exchange is focused (concentrated) on relatively few trading partners. Using the same convention as the HHI measure, concentration is a function of the sum of the squares of each trading partner's information share for the period. Multiplying the resulting sum by 10,000 conforms to the industrial organization literature where values that approach zero represent fragmentation and values approaching 10,000 represent high concentration.

$$\text{CONCENTRATION}_{it} = \sum \left[\text{information\_share}^2_{ijt} \right] \text{ x } 10{,}000 \qquad [5.4]$$

Control Variables

Firm Size

Studies have recognized that larger firms experience economies of scale in their inventory turnover such that there is a positive correlation between inventory turnover and firm size (Gaur et al. 2005). Controlling for firm size can minimize the confounding effects. Firm size may be measured as total assets, sales, and the number of employees which have been found to be highly correlated (Zhu and Kraemer 2002). For the purposes of the study, firm total assets reported quarterly in the Compustat database is used as the measure of firm size.

Sales Surprise

Unexpected demand events affect a firm's inventory turnover. If sales are higher than anticipated, then average inventories will be driven down during the period resulting in a higher reported inventory turnover ratio. Similarly, if sales are lower than anticipated, inventories will be inflated during the period resulting in a lower reported inventory turnover.

The effects of sales surprise were specifically addressed and found to be significantly positively related to inventory turnover performance (Gaur et al. 2005). Sales surprise is a function of the difference between management's forecast of sales and the actual sales experienced during a specific time period. Unfortunately, a firm's sales forecast is not publicly reported requiring that an appropriate forecast be used as a proxy. This study uses a moving average forecast to estimate the sales for each quarter. A full treatment of the development and selection of this forecast method is included in Appendix F.

Sales surprise has been measured as the simple ratio of actual observed sales for a period to the sales forecast for the period (Gaur et al. 2005). The resulting measure indicates the relationship between forecast and actual sales. Sales surprise values between zero and one indicate that the actual sales were greater than the forecast. In this case, the forecast overestimated actual sales for the period. Sales surprise values of one indicate that the forecast exactly estimated sales and values greater than one indicate that the forecast underestimated actual sales for the period.

$$SURPRISE_{it} = \frac{\text{Actual\_Sales}_{it}}{\text{Forecasted\_Sales}_{it}} \qquad [5.5]$$

Seasonality

Depending on the focal industry, inventory turnover can be affected by the seasonality of sales. In retail trade, firms may intentionally build up inventory in anticipation of large selling seasons such as the winter holidays. For the purposes of this study, dummy variables are used to control for quarterly seasonality. Three binary dummy variables are used to identify first, second, and third quarter. The fourth quarter is used as the base period.

Prior Period Inventory Turnover

One of the greatest drivers of inventory turnover during a given period is the inventory turnover in the prior period. This firm level effect is controlled by including the prior period inventory turnover as a control variable in the regression. Use of this lagged variable controls for any unobserved heterogeneity.

5.3.3 Panel Data Analysis

Panel data analysis supports the study of longitudinal datasets where multiple observations are included for each participant. Panels are made up of cross-sections of firm level observations that are then repeated for multiple time periods which allows for the analysis of firm actions over time. This combination of cross-section and time series allows for analysis not supported by standard regression tools due to a violation of the assumption of independence of observations. A panel data set allows for this by controlling time-specific and firm-specific effects and has been used in prior longitudinal studies where multiple observations of a firms occur within each cross-section (Hitt 1999; Mukhopadhyay et al. 1995). This study uses subscripts to account for time-specific (t=1, …., 8) and company-specific (i=1,…, 39) effects. Since both the dependent and independent variables are focused on the operational level of the firm, all explanatory variables are measured in the same quarter with no lagging.

$$\begin{aligned}\log(\mathrm{INVENTORY\_TURNOVER}_{it}) &= \beta_0 + \beta_1 \log(\mathrm{CLOSE}_{it}) + \beta_2 \log(\mathrm{CHURN\_RATE}_{it}) + \\ &\beta_3 \log(\mathrm{ASYMMETRY}_{it}) + \beta_4 \log(\mathrm{CONCENTRATION}_{it}) + \sum_{i=0}^{n} \gamma_i \mathrm{ControlVariables}_{it}\end{aligned} \qquad [5.6]$$

For simplicity, the model is first estimated using an ordinary least squares (OLS) regression. The OLS assumptions of homoskedasticity and independence of observation are often violated in panel datasets. To test the assumption of homoskedasticity, the Breusch-Pagan/Cook-Weisberg Lagrange multiplier test is used (Breusch and Pagan 1979; Greene 2002). This test provides a test statistic of 29.63 based on a $\chi 2$ distribution.

The null hypothesis of constant variance is rejected at a statistical significance level of less than one percent.

An additional test for the existence of serial correlation in the residuals is also recommended. The Wooldridge procedure provides a test of the null hypothesis that no serial correlation exists (Wooldridge 2002). Results of the Wooldridge procedure showed the presence of serial correlation based on an F-statistic of F=110.351 which is statistically significant at the less than one percent level. Greene (2003) recommends the use of a generalized least squares (GLS) procedure to estimate the model when preliminary tests indicate the presence of heteroskedasticity and serial correlation.

The GLS specification allows for the estimation of both random and fixed-effect estimators. In the fixed effects model (fe), the constant term is adjusted for the panel and time period. The random effects model (re) assumes that the unobserved individual heterogeneity is independent of the regressors. The random effects model is preferred due to its avoidance of large numbers of dummy variables which decreases the degrees of freedom allowed for statistical testing. Although preferred for efficiency, the random effects model produces inconsistent coefficient estimates when the panel and time effects are in fact correlated with the regressors. The Hausman specification test compares the fixed and random effects under the null hypothesis that random effects are uncorrelated with other regressors (Greene 2002; Hausman 1978). If the individual effects are correlated, a random effects model will produce biased estimates.

The Hausman test provides a Wald test statistic (W) based on a $\chi 2$ distribution with *K-1* degrees of freedom. For this panel dataset, the result of the Hausman test is

W=50.68 which is significant at the one percent level. The null hypothesis that the difference in the coefficients is not systematic is rejected supporting the use of a fixed effects specification.

5.3.4 Descriptive Statistics

Table 5.1 summarizes explanatory variables for firms in the sample. The variables are presented in their unlogged form to simplify the interpretation of the descriptive statistics. As noted in Chapter 4, explanatory variables have been modeled using a natural log translation to adjust for kurtosis and skewness. In this sample, all four explanatory variables (CLOSE, ASYMMETRY, CONCENTRATION, and CHURN_RATE) were not within an acceptable range of kurtosis and skewness in order to be considered as normally distributed. Natural log transformations were used to correct for this prior to modeling the variables through regression.

Table 5.1 Descriptive Statistics of Unlogged Variables

	N	Mean	S.D.	Min	Max
INVENTORY_TURNOVER	191	8.3588	14.4869	1.2630	94.5590
CLOSE	191	0.4662	0.2209	0.0192	0.8724
CHURN	191	0.0744	0.0716	0.0072	0.5862
ASYMMETRY	191	0.3362	0.2129	0.0032	0.9291
CONCENTRATION	191	1,100.98	1,093.15	51.36	6,440.91
Control Variables					
FIRMSIZE	191	18,303.71	15,501.83	1,003.35	63,076.00
SALES_SURPRISE	191	1.0577	0.1551	0.6936	1.7553
INVX_LAG	191	1.7008	0.7263	0.2270	4.5492
SEASON1DUMMY	191	0.1780	0.3835	0.0000	1.0000
SEASON2DUMMY	191	0.3298	0.4714	0.0000	1.0000
SEASON3DUMMY	191	0.3141	0.4654	0.0000	1.0000

The firms in the study vary in inventory turnover between 1.26 and 94.56. This is a result of the wide range of industries included in the sample, particularly within the manufacturing segment. Manufacturing firms represent both the highest and lowest inventory turnover measures. The two high-technology manufacturing firms in the sample have inventory turnover greater than 60 for each of the reported quarters. Pharmaceutical manufacturers represent the lowest reported inventory turnover of less than two for all reported quarters.

Wholesale and retail trade firms in the sample show clustered results with respect to inventory turnover. The average inventory turnover for wholesale trade and retail trade firms was 6.43 and 4.56 respectively. Both are clearly below the overall mean of 8.3588 which is being inflated by the higher average inventory turnover of manufacturing firms.

The percentage of trading partner relationships characterized by high levels of both transactional and extended information exchange ranges from zero to eighty-nine percent. The measure is the proportion of trading partner relationships identified as close so a mean of 0.4662 and standard deviation of 0.2209 indicate that the firms are spread across the range of values between zero and 0.8724. A firm with a CLOSE measure of 0.45 has close relationships with forty-five percent of its trading partners.

The turnover of trading partner relationships is measured by the CHURN variable. The average trading partner turnover ratio is seven percent and ranges from zero to fifty-nine percent.

The ASYMMETRY measure captures the scaled difference between the volume of information that a technology champion firm sends to the volume of information that they receive. This value could range from zero to 1.00. As the measure approaches zero it indicates a balanced approach to the sending and receiving of information. As the measure approaches 1.00, firms are showing a greater imbalance or asymmetry between the volume of information sent and volume of information received. The mean of this sample is 0.3362 which reflects that overall, the technology champion firms trend toward a balance of sending and receiving volumes. Technology champion firms in the sample reported values ranging from zero (a completely balanced strategy) to 0.89 which indicates a high asymmetry of information exchange. These descriptive statistics support the notion that technology champion firms vary in the level of asymmetry between the volume of information they send and receive.

The CONCENTRATION of information exchange within the trading partner portfolio is an additional measure of how the firm leverages its use of information. The values can range from zero to 10,000 with higher values identifying strategies where information exchange is concentrated with few trading partners rather than shared equally across the trading partner portfolio. The mean value for information exchange concentration is 1,100 which is closer to a fragmented strategy; however, the actual values range from 51 (highly fragmented) to 6,440 (concentrated).

The potential number of observations in the panel dataset is 312 (39 technology champion firms for 8 quarters). The actually number of observations in the final model is 191 which is a result of missing values. Specifically, 40 observations are lost due to the lagging of inventory turnover since the inventory turnover for the period prior to quarter 1 is not included. Nine observations are lost due to the dependent variables (INVENTORY_TURNOVER) not being available from the Compustat database. Twenty-three observations are dropped due to technology champion firms not participating in the EDI network during select quarters. An additional 49 observations are dropped due to the log transformation of explanatory variables with values of zero. The remaining 191 observations are included for the calculation of descriptive statistics, pairwise correlations, and the coefficient estimates.

The correlation matrix for the explanatory variables provided in Table 5.2 identifies three statistically significant relationships among the explanatory variables. The use of close trading partner relationships (CLOSE) shows a positive and statistically significant correlation with information exchange asymmetry (ASYMMETRY). This correlation is at the fourteen percent level. Information exchange concentration (CONCENTRATION) is positively correlated with the churn rate (CHURNRATE) at a twenty-five percent level. Information exchange concentration is negatively correlated with information exchange asymmetry at the twelve percent level.

Table 5.2 Pairwise Correlations

	CLOSE	CHURN_RATE	ASYMMETRY	CONCENTRATION	FIRM_SIZE	SALES_ SURPRISE	INVX_LAG	SEASON1 _DUMMY	SEASON2 _DUMMY	SEASON3 _DUMMY
CLOSE	1									
	191									
CHURN_RATE	0.0480	1								
	0.5098									
	191	191								
ASYMMETRY	***0.1432***	0.0871	1							
	0.0480	0.2610								
	191	191	191							
CONCENTRATION	0.0986	***0.2564***	***-0.1230***	1						
	0.1750	***0.0003***	***0.0900***							
	191	***191***	***191***	191						
FIRM_SIZE	-0.0992	***-0.1297***	***-0.1897***	-0.0442	1					
	0.1721	***0.0736***	***0.0086***	0.5440						
	191	***191***	***191***	191	191					
SALES_SURPRISE	***-0.1362***	-0.0386	0.0623	-0.0887	0.0379	1				
	0.0603	0.5957	0.3918	0.2222	0.6030					
	191	191	191	191	191	191				
INVX_LAG	***-0.1973***	***0.1442***	***0.1374***	0.0606	-0.1133	***0.1722***	1			
	0.0062	***0.0465***	***0.0581***	0.4050	0.1186	***0.0172***				
	191	***191***	***191***	191	191	***191***	191			
SEASON1_DUMMY	-0.0510	-0.0679	0.0003	0.0566	0.0414	***-0.1615***	0.0682	1		
	0.4834	0.3505	0.9963	0.4367	0.5696	***0.0256***	0.3486			
	191	191	191	191	191	***191***	191	191		
SEASON2_DUMMY	0.0558	0.0710	-0.0149	-0.0312	-0.0313	-0.0851	0.0236	***-0.3265***	1	
	0.4433	0.3292	0.8374	0.6678	0.6671	0.2417	0.7358	***0.0000***		
	191	191	191	191	191	191	191	***191***	191	
SEASON3_DUMMY	-0.0104	0.0285	0.0205	-0.0123	-0.0206	-0.0965	-0.0595	***-0.3149***	***-0.4748***	1
	0.8865	0.6958	0.7782	0.8660	0.7772	0.1842	0.4134	***0.0000***	***0.0000***	
	191	191	191	191	191	191	191	***191***	***191***	191

The levels of correlation between explanatory variables are below the level at which multicolinearity would bias coefficient estimates. An additional test of the variance inflation factors (VIF) for the independent variables was conducted. Results from the VIF test shown in Table 5.3 indicate that inflation is less than two for each of the explanatory variables. The VIF for two of the seasonality control variables are greater than two, however, since the coefficients of the seasonality variables will not be interpreted in order to test the hypotheses the marginally high VIF is not detrimental to the model. A VIF of less than two is within the acceptable range to assume that multicolinearity is not adversely affecting the coefficient estimates.

Table 5.3 Variance Inflation Factor Results

Variable	VIF
CLOSE	1.16
CHURN_RATE	1.16
ASYMMETRY	1.08
CONCENTRATION	1.17
FIRM_SIZE	1.05
SALES_SURPRISE	1.28
INVX_LAG	1.20
SEASON1_DUMMY	1.94
SEASON2_DUMMY	2.16
SEASON3_DUMMY	2.12
Mean VIF	1.43

5.4 Results

The GLS regression provides coefficient estimates for all modeled explanatory and control variables as reported in Table 5.4. The model fit is statistically significant based on a F-statistic of 36.40 and a χ^2 distribution. The explanatory power of the model is identified by a high R-squared value for both the between group and within groups variance.

The coefficient for the logged measure of trading partner closeness log(CLOSE) is statistically significant and negative. The coefficients for the remaining three explanatory variables are not statistically significant. Statistically significant and positive coefficients were estimated for the logged sales surprise log(SURPRISE) and lagged inventory turnover log(INVX_LAG) control variables. A statistically significant negative coefficient was estimated for the seasonality control variable for the second quarter of each year (SEASON2DUMMY). The statistically significant positive coefficient for the logged sales surprise control variable log(SURPRISE) is interesting. The positive coefficient indicates that greater levels of surprise are positively related to increases in inventory turnover. Since SURPRISE is measured as the ratio of actual sales to forecasted sales, this indicates that when actual sales are greater than expected the inventory turnover is improved. Intuitively this makes sense since having sales greater than expected may drive inventory to artificially low levels. As noted by Gaur et al. (2005) these unexpected events can affect inventory performance measures and should be controlled for separately in the regression.

This study finds an important result showing a relationship between the nature of supply chain relationships and supply chain performance. Since the literature does not have a clearly hypothesized relationship between these two variables, this study has proposed hypotheses in both directions. The results support Hypothesis 4 Alternative: The greater use of close trading partner relationships is negatively related to supply chain performance. This helps confirm some of the prior literature on this subject that describe the benefits of arms-length relationships to supply chain management (Lambert et al. 1996b; Lambert et al. 2004; McCutcheon and Stuart 2000) and contradicts other literature that describes the benefits of close relationships (Anderson and Narus 1990; Goffin et al. 2006; Webster 1992). Hypotheses 5, 6, and 7 are not supported.

Table 5.4 Coefficient Estimates: Full Network Model

n		191
groups		39
R-squared	within	0.7194
	between	0.9974
	overall	0.9961
F		36.40
Prob>F		0.0000

(log)INVENTORY_TURNOVER	Coef. (Std Err)	P>| t |	sig	Hypothesis Testing
Explanatory Variables				
(log)CLOSE	-0.0197 (0.0086)	0.024	*	H4: Not Supported H4 Alternative: Supported
(log)CHURN_RATE	0.0002 (0.0032)	0.950	ns	H5: Not Supported
(log)ASYMMETRY	0.0015 (0.0043)	0.727	ns	H6: Not Supported
(log)CONCENTRATION	0.0142 (0.0086)	0.101	ns	H7: Not Supported
constant	0.2862 (0.3302	0.388	ns	
Control Variables				
(log)FIRMSIZE	0.0108 (0.0328)	0.742	ns	
(log)SALES_SURPRISE	0.0343 (0.0166)	0.041	*	
(log)INVX_LAG	0.7158 (0.0410)	0.000	**	
SEASON1DUMMY	-0.0101 (0.0065)	0.126	ns	
SEASON2DUMMY	-0.0107 (0.0055)	0.056	+	
SEASON3DUMMY	-0.0087 (0.0056)	0.121	ns	

**<.01 *<.05 +<.1 significance level

5.5 Discussion

The support of Hypothesis 4 Alternative is a significant contribution of this dissertation. Through the use of multi-firm archival data, the negative relationship between firm performance and the use of close trading partner relationships supports research on the detrimental performance effects in relationships where opportunism may be more prevalent. Marketing literature has noted a similar situation where close relationships create an atmosphere where trading partners become complacent (Wathne and Heide 2000). This passive form of opportunism is described as shirking and may occur when trading partners fail to perform because the relationship is not seen as being at risk.

This contribution to the literature is a significant finding of the dissertation. An additional post-hoc analysis is provided to further refine the impact of close relationships by considering the effects separately for three echelons of the supply chain (manufacturers, wholesalers, and retailers).

Since this electronically-mediated network includes technology champion firms from three echelons of the supply chain, additional regressions were generated to separately evaluate the echelon effects. As shown in Table 5.5, all three regressions are significant based on their F-test. Coefficient estimates vary depending on the supply chain echelon.

Table 5.5 Coefficient Estimates: Echelon Model

	Manufacturers			Wholesalers			Retailers		
(log)INVENTORY_TURNOVER	Coef. (Std Err)	P>| t |	sig	Coef. (Std Err)	P>| t |	sig	Coef. (Std Err)	P>| t |	sig
Explanatory Variables									
(log)CLOSE	-0.0193 (0.0090)	0.036	*	-0.0703 (0.0530)	0.204	ns	-0.0339 (0.0236)	0.161	ns
(log)ASYMMETRY	-0.0007 (0.0049)	0.894	ns	0.0375 (0.0396)	0.358	ns	0.0124 (0.0070)	0.086	+
(log)CONCENTRATION	0.0065 (0.0102)	0.527	ns	0.0098 (0.0235)	0.683	ns	0.0278 (0.0170)	0.112	ns
(log)CHURN_RATE	-0.0088 (0.0040)	0.031	*	0.0039 (0.0094)	0.687	ns	0.0088 (0.0051)	0.091	+
constant	0.0068 (0.5119)	0.989	ns	0.6437 (1.0435)	0.547	ns	0.8937 (0.3516)	0.015	*
Control Variables									
(log)FIRMSIZE	0.0216 (0.0498)	0.665	ns	-0.0282 (0.1156)	0.810	ns	-0.0736 (0.0374)	0.057	+
(log)SALES_SURPRISE	0.1724 (0.0277)	0.000	**	0.0300 (0.0604)	0.627	ns	-0.0460 (0.0237)	0.059	+
(log)INVX_LAG	0.8278 (0.0546)	0.000	**	0.7573 (0.1458)	0.000	**	0.0742 (0.0606)	0.000	**
SEASON1DUMMY	-0.0057 (0.0079)	0.427	ns	-0.0106 (0.0156)	0.508	ns	-0.0218 (0.0104)	0.043	*
SEASON2DUMMY	-0.0137 (0.0068)	0.047	*	0.0014 (0.0139)	0.919	ns	-0.0222 (0.0101)	0.034	*
SEASON3DUMMY	-0.0037 (0.0071)	0.603	ns	0.0033 (0.0140)	0.818	ns	-0.0148 (0.0088)	0.101	ns

**<.01 *<.05 +<.1 significance level

Regression Statistics

	Manufacturers	Wholesalers	Retailers
n	104	30	57
groups	23	5	11
R-square within	0.8033	0.8450	0.8677
R-square between	0.9982	0.9831	0.8550
R-square overall	0.9976	0.9751	0.8436
F	29.00	8.18	23.62
Prob>F	0.0000	0.0002	0.0000

The inventory performance of manufacturers is negatively affected by the use of close trading partner relationships as measured by (log)CLOSE. This result may be related to the particular supply needs of manufacturers. Research into the relationship between buyers and suppliers has recognized that the complexity of inputs affects the governance of the relationship and how electronic integration is implemented (Hess and Kemerer 1994; Mukhopadhyay et al. 1995). When more complex or specialized inputs are required, asset specificity may become a factor where the close relationships create an environment for opportunistic behavior for the trading partner (Williamson 1975).

The stability of the trading partner portfolio, as measured by the (log)CHURN_RATE variable, has a negative effect on inventory turnover for manufacturing firms. Again this may be related to the types of inputs and processes used by manufacturers that are unique from those used in other echelons of the supply chain. The investment in time needed for relationships to develop in order to maintain appropriate flow and quality of inputs for manufacturers may be adversely affected by high levels of instability in the trading partner portfolio. The positive coefficient estimates for (log)SALES_SURPRISE and (log)INVX_LAG are not surprising as discussed previously for the full network model results.

The wholesaler echelon model is also statistically significant based on an F-test; however, the coefficients estimated for the explanatory variables were not statistically significant. The coefficient for the lagged inventory turnover variable, (log)INVX_LAG, is statistically significant and positive as previously discussed for the full network model results. The lack of statistically significant coefficient estimates for the explanatory variables is very likely related to the small number of wholesalers included in the sample.

The results from the retailer model are statistically significant based on an F-test, with coefficient estimates that vary from those for the manufacturing echelon. The retailers do not show a significant relationship between the use of close trading partner relationships and inventory turnover. Unique to the retailer echelon, the balance of sending and receiving information, (log)ASYMMETRY, is positively related to inventory turnover. Contrary to the results for manufacturers, retailers are found to have a positive relationship between the (log)CHURN_RATE and inventory turnover. This positive relationship may be related to the type of inputs used by retailers. Since retailers often resell standard products, retailers may be more price driven such that instability in the trading partner portfolio allows them to constantly renegotiate prices with their suppliers. This position may be complimented by the findings that close relationships do not have a statistically significant effect on inventory turnover but the asymmetry of information has a positive effect. The positive coefficient indicates that receiving more information than they send is beneficial to inventory turnover. The asymmetric availability of information has been noted for allowing firms to disproportionately retain the benefits of the relationship (Clemons and Hitt 2004). Research has found that asymmetries of information driven by the more powerful retailer might be overcome by the supplier as a level dependency develops (Narayandas and Rangan 2004). However, the retailer may not become dependent on individual suppliers if the churn rate of their trading partner portfolio is high as indicated by results from this sample. The retailers also show a statistically significant negative effect for two of the seasonality control variables. Both SEASON1DUMMY and SEASON2DUMMY are negative for the retailer model. This indicates that retailer inventory turnover is lower due to timing effects of first and second quarter. The manufacturer model also showed negative seasonal significance but only for the second quarter. It appears that retail trade is more sensitive to quarterly seasonality.

To further test the effects of information asymmetry for retailers, the measure was recalculated using an alternate operationalization. The modified asymmetry measure allows for a directional measure by removing the absolute value for the difference between the receive volume and the send volume for each technology champion firm and quarter. This modified measure allows the resulting ratio to provide negative and positive values. A negative ratio indicates that the technology champion firm is sending more information to its trading partners during the quarter relative to the volume received. A positive ratio indicates that they are receiving more information than they send. The equation used to calculate the alternative operationalization is shown in Equation 5.7.

$$ASYM\_DIRECTION_{it} = \frac{Receive\_Volume_{it} - Send\_Volume_{it}}{Total\_Volume_{it}} \qquad [5.7]$$

The resulting coefficient estimate for the directional asymmetry measure is positive and statistically significant for retail firms. This finding indicates that for retailers it is better to receive information from their trading partners than to send information to their trading partners.

The value of this insight that the effect of closeness of trading partners varies depending on the firm's location in the supply chain has an important implication for the supply chain management literature. First, it demonstrates that when examining supply chain performance, one should include measures that describe the level of closeness of the trading partners and control for the location of the focal firm within the supply chain. As this study finds, there is support for a negative association between trading partner closeness and supply chain performance for manufacturers but not specifically for wholesalers or retailers. Second, the study helps with the literature on vendor managed inventory (VMI). Subsequent VMI studies may want to include whether or not VMI helps in light of the additional power that a vendor may have over the customer. The effects of closeness may be moderated by other relational factors. These factors may include the age of the relationship, the level of dependence, and the asymmetry of information exchange. Third, this finding highlights the importance of market forces in increasing supply chain performance. Research that models supply chain partners as monopolies (i.e. the Beer Game) may overstate the problems of supply chain performance because they do not consider the benefits of market forces. In real-world settings, such as the context of this dissertation, firms may use arms-length relationships to increase their supply chain performance.

The negative impact of close trading partner relationships on supply chain performance may be explained by opportunism. Opportunistic behavior by close trading partners had been described in complimentary research. Passive forms of opportunism can occur when close trading partners become complacent and do not see the relationship as being at risk. As a result they may not put forth the effort to meet and exceed expectations which has been described as shirking (Wathne and Heide 2000). A more aggressive form of close trading partner opportunistic behavior occurs when information gained through the relationship is misappropriated. This behavior has been described as poaching (Clemons and Hitt 2004).

This important finding of the study linking the value of arms-length relationships to supply chain performance has managerial implications. First, managers may not want to create close relationships with too many trading partners. Over time, this may only increase the power of the trading partner. Managers may be most sensitive to this power as it relates to more unique inputs such as those used by manufacturers compared to retailers. However, managers may consider that relationship closeness can also result in higher inventory costs when close trading partners become complacent and might not work as aggressively to find new efficiencies. Second, if a manager does rely on close relationships with trading partners, he may want to structure his contracts such that they include incentives to encourage supply chain performance improvements. For example, a manager may ask a supplier for a "service level agreement" that specifies the minimum supply chain performance level or else be subject to penalties. Furthermore, the customer can give financial incentives if the supplier helps them achieve higher levels of supply chain performance. Third, it may give managers a reason to shy away from "sole-source" contracts. When looking to procure new material and services, a supply chain manger may want to ensure a plurality of suppliers to allow for the benefits of market forces to help improve supply chain performance.

5.5.1 Alternative Explanatory Variables

Although Hypothesis 4 Alternate was supported in the overall model, results for the other three hypotheses in this study were not significant. Future research may consider alternative specification of the variables in order to understand these relationships in more detail. For example, the hypothesis that describes trading partner churn rate could consider churn among the close and arms-length trading partners separately. If close relationships hurt supply chain performance—a hypothesis that is supported by the results of this study—then customers may use a process of continual evaluation of their close relationships and use the threat of ending this relationship if the customer thought the trading partner was acting opportunistically. Another possible operationalization of the churn rate variable may only consider the fraction of information exchange that are new in each quarter instead of the fraction of new trading partners. This alternative operationalization may give more appropriate weight to the close trading partner relationships. Similarly, the information asymmetry and information concentration measures were for the entire technology champion firm. Future research could measure these variables just for trading partner relationships identified as close. As shown in the post-hoc analysis, it is also important to include the echelon effects when modeling supply chain interaction.

Since strong negative results were found the manufacturer's use of close trading partner relationships, additional research could focus on how manufacturers manage their portfolio of trading partners. Specifically, measures can be developed that compare the balance between the use of close and arms-length relationships. To this end an additional post-hoc analysis is provided to begin exploring this extension of the dissertation. Focusing on the diagonal axis between quadrant II Close Relationships and quadrant III Arms-length Relationships, a measure of how manufacturing firms balance their trading partner portfolio is calculated. The preliminary measure (AXIS_DIFFERENCE) tests the difference between the percentage of trading partners characterized as close and the percentage of trading partners characterized as arms-length.   This new measure is substituted into the previous performance model as shown in Equation 5.8.

$$\begin{aligned}\log(\mathrm{INVENTORY\_TURNOVER}_{it}) &= \beta_0 + \beta_1 \log(\mathrm{AXIS\_DIFFERENCE}_{it}) + \beta_2 \log(\mathrm{CHURN\_RATE}_{it}) + \\ &\beta_3 \log(\mathrm{ASYMMETRY}_{it}) + \beta_4 \log(\mathrm{CONCENTRATION}_{it}) + \sum_{i=0}^{n} \gamma_i \mathrm{ControlVariables}_{it}\end{aligned} \qquad [5.8]$$

The modified model is then regressed using the manufacturing subset of the panel dataset.   Initial results from this model do not provide an improvement on the previous model. The coefficient estimated for the portfolio balance measure (AXIS_DIFFERENCE) is not statistically significant, however, this next step moves the research further in testing the portfolio perspective introduced with Hypothesis 4 Alternative.

Similarly, the operationalization of the CLOSE variable is proposed as a relative measure for each technology champion firm in the dataset. As noted previously, a technology champion firm is determined to be closet to its trading partner on the champion's average volume of transactional and enhanced information exchange (see Figure 2.2). An alternative to using the firm mean values is to use the echelon mean values to calculate the percentage of transactions with close trading partners. The echelon-based alternative operationalization of the CLOSE variable is substituted into the original regression model shown in Equation 5.6. The coefficient estimate for the alternative measure of the CLOSE variable is negative and statistically significant. This result is consistent with the original operationalization of the CLOSE variable.

Although additional work is needed, these analyses illustrate that the existing archival dataset can provide additional measures of how a firm's portfolio of trading partners is leveraged and potentially affects firm performance. Future research should seek additional methods of operationalizing these measures.

5.5.2 Alternative Lagged Explanatory Variables

The current model and hypothesis associate explanatory variables and the independent variable from the same time period. Extant research focusing on operational performance and operational activities supports the time period matching used in this study (Mukhopadhyay et al. 1995). Research in the area of IT investment has supported that there are lagged effects of investments on performance (Brynjolfsson et al. 1994).

To incorporate this perspective, each of the explanatory variables is modeled using a one period lag. Summary results are provided in Table 5.6.

Table 5.6 Alternate Lagged Model

n		225
groups		39
R-square	within	0.6949
	between	0.9984
	overall	0.9968
F		40.08
Prob>F		0

Explanatory Variables			
(log)CLOSE_LAG	-0.0090 (0.0087)	0.300	ns
(log)ASYMMETRY_LAG	0.0048 (0.0041)	0.231	ns
(log)CONCENTRATION_LAG	0.0140 (0.0080)	0.080	+
(log)CHURN_RATE_LAG	0.0007 (0.0030)	0.809	ns
constant	0.3401 (0.3301)	0.304	ns
Control Variables			
(log)FIRMSIZE	0.0020 (0.0336)	0.952	ns
(log)SALES_SURPRISE	0.0646 (0.0168)	0.000	**
(log)INVX_LAG	0.7350 (0.0392)	0.000	**
SEASON1DUMMY	0.0031 (0.0064)	0.630	ns
SEASON2DUMMY	0.0026 (0.0052)	0.623	ns
SEASON3DUMMY	-0.0003 (0.0052)	0.953	ns

**<.01 *<.05 +<.1 significance level

The results in Table 5.6 show changes in the model fit and the estimated coefficients. The alternative lagged model is statistically significant based on the F-statistic but shows a slight decrease in the R-square measuring the explanatory power of the model. The trading partner closeness variable (CLOSE) is not statistically significant in the logged model. Additionally, the information exchange concentration measure (CONCENTRATION) is now statistically significant and positive which supports Hypothesis 7: greater information exchange concentration is positively associated with supply chain performance. Since Hypothesis 7 is only supported in the lagged model, this suggests that prior trading partner portfolio activities may contribute to performance in future periods.

5.5.3 Alternative Dependent Variables

Inventory turnover was selected for use as the primary performance measure in this study due to its prominent use in extant supply chain literature and theorized association with information exchange. Alternative performance measures are tested for comparison. The Compustat database provides additional quarterly firm performance measures that may be considered for supply chain research.

Specifically, receivables turnover and net income are tested as alternative dependent variables in the original model. Summary results and model statistics are included in Appendix G. The net income performance (NET_INCOME) dependent variable provides similar coefficient estimates to the original model. The measure of trading partner closeness (CLOSE) is positive and statistically significant. The receivables turnover performance (RECEIVABLES_TURN) does not provide statistically significant coefficient estimates for any of the explanatory variables. As a further test of the potential relations between the relations between the alternative dependent variables, a correlation matrix is provided in Table G.3 of Appendix G. There is no statistically significant correlation between inventory turnover performance and either of the alternative dependent variables. There is a statistically significant negative relationship between receivables turnover performance and net income. This correlation is at the 18% level. Further study beyond this dissertation is needed to gain understanding of how this negative relationship can be interpreted.

Although the use of net income provides similar coefficient estimates, the R-square statistics are lower in the alternate model. This is not surprising since net income is affected by many factors beyond the operation of the supply chain. It is not surprising that the operation of the supply chain has some effect on firm net income.

5.5.4 Additional Future Research Notes

Future research may also focus on reconciling the disparate positions of Hypotheses 4 and Hypothesis 4 Alternative. The potential balance between the use of close and arms-length relationships could be tested as a non-linear relationship where too close and too arms-length is detrimental to inventory turnover. The use of a squared variable of closeness could be developed to identify a u-shaped relationship between relationship closeness and firm performance (Steckel et al. 2004). Additionally, the seasonality control variable may be expanded. The current control variable controls for overall seasonality across the year but does not account for seasonality within a firm. A possible alternative would be to use the sales variations between quarters as a firm measure of seasonality.

Additional firm level measures may support the control of firm effects. The currently modeled lagged inventory turnover measure captures much of the heterogeneity of firms. The firm's experience, strategy, and effectiveness in managing inventory are captured within this control variable. The development of additional measures could control individually for these sources of variation. A survey instrument targeting the technology champion firms could provide additional firm-level data that may improve the control variables used in the model.

In this study, the roles of buyer and supplier have not been identified. Inclusion of this information could improve the generalization of any results. The archival data was analyzed to identify the roles with the network, however, results were inconsistent. Supply chain research has recognized that a firm is both a buyer and supplier depending on whether it is securing inputs or distributing outputs (Stevenson 2007). In practice this can occur when a manufacturer such as 3M the supplier of adhesive products to a wholesaler such as W.W. Grainger. The roles reverse when W.W. Grainger supplies parts to support the maintenance of 3M's production equipment. A survey instrument may be better suited for collecting data on the primary role of each party in a dyadic relationship.

The initial model included all three echelons of the supply chain for hypotheses testing. As supported by the post-hoc echelon models, future research may develop and test hypotheses based on distinct echelon characteristics. Retail firms in particular are unique because their electronically mediated trading partner relationships are exclusively suppliers. The customers of retail firms do not interact with the technology champion firm through the use of an EDI network. Conversely, the portfolio of electronically mediated trading partners for manufacturers and wholesalers includes both suppliers and customers. These distinctions could be measured and then tested by regressing subsets of the data based on the location in the supply chain.

5.6 Conclusion

Overall, this study highlights the growing importance of supply chain context on supply chain performance. Although much of the literature suggests that close relationships in the supply chain are always desirable, there may be contextual issues that require some relationships to remain arms-length (Webster 1992). Through case analyses, researchers suggest that supply chain relationships are best when developed at the appropriate level of closeness depending on the context of the relationship (Goffin et al. 2006; Lambert et al. 2004). This supports that although the benefits of close relationships are known, not all interfirm exchanges can support close relationships.

Chapter 6: Conclusion

6.1 Contribution

The contribution of this dissertation is four-fold. First, from a measurement standpoint, this dissertation uses existing theory to develop unique objective measures of information exchange to examine inter-firm relationships and performance. Previous literature has been limited to perceived measures of information exchange or modeling to examine the effects of information exchange. This unique dataset supported the development of objective measures of information exchange. Second this dissertation has extended the supply chain literature by building knowledge of the performance effects of interfirm relationships. Firm performance and trading partner performance are examined based on supply chain interaction through information exchange. Third, this dissertation incorporates methodology from strategic management to examine relationship termination as a measure of trading partner performance. Fourth, this dissertation extends theory through empirical evidence to improve the understanding of the relationship between trading partner closeness and firm performance.

By using multiple units of analysis and measures of performance, two important results are found from each study. From the termination study presented in Chapter 4, a u-shaped relationship is found between the volume transactional information exchange and relationship termination. Although it has been common practice to expect relationships to survive when transactional exchanges are occurring, it is counter-intuitive to suggest that at higher levels of transactional exchange the likelihood of termination increases. Additionally, a u-shaped relationship is also found between the volume of enhanced information exchange and relationship termination.

Two additional results come from the performance study in Chapter 5. First, close relationships can be detrimental to the technology champion firms as measured by inventory turnover. This finding is consistent with other research into the management of trading partner relationship portfolios (Lambert et al. 1996b; Lambert et al. 2004), which finds merely having close relationships with trading partners is not sufficient. It is more important to have the right balance of trading partner relationships within the firm's portfolio of trading partners. Second, a firm's position in the supply chain matters. The relationship characteristics and inputs may be unique for firms depending on their location within the supply chain. Inputs for manufacturers may be more specific and require stable relationships and close coordination to support production processes. These two factors together may have conflicting effects on inventory turnover. Conversely, retailers may benefit from the price mechanism effects of switching trading partners often but gain little value from close relationships due to the commodity nature of their inputs.

6.2 Managerial Implications

From both the results of this dissertation and extant literature, the exchange of information is shown to have performance implications. The way in which firms exchange information has significance beyond transactional data processing efficiency. The exchange of information has long-term implications because of its effects on the competitive position of the firm.

Managers may consider the use of information exchange to stabilize supply chain relationships. Stability in a relationship has the benefit of allowing trading partners to focus on long-term valuing adding initiatives. When firms are unsure of future transactions, they may be reluctant to make investments in the relationship (Bensaou and Anderson 1999). Conversely, stability in the trading partner portfolio may lead to complacency where trading partners focus on other relationships without fear of termination. New trading partners may allow the firm to achieve lower input prices, new partners may be more sensitive to customer services, and new relationships may allow for new ideas and perspectives. However, forming new trading partner relationships has its costs. There is often a significant fixed cost with establishing a new relationship. This can come in the form of investments in communication or transaction technology or even the cost of contracting. Overall, the stability or instability of supply chain relationships is an important strategic question for managers to address.

Managers should consider the benefits of the firm's portfolio of suppliers as it relates to the supply chain performance of a firm. First, it may be possible to find some win-win situations where both the firm and its trading partner can benefit. This may be because of increased sharing of forecasting and inventory information. Second, it may be possible to change the allocation of the value between a firm and its trading partner. As this dissertation indicates, the value may be greater for the supplier than for the customer when there is a close relationship between the two. Overall, managers may consider their network of relationships with its trading partners similar to the way it views an investment portfolio. Diversification between close and arms-length relationships may have great strategic advantages. If the manager relies too much on arms-length relationships and market forces, then the firm will face the costs related to continually adjusting to new trading partner relationships. On the other extreme, too much reliance on close relationships may lead to reduced supply chain performance captured by inventory turnover. Accordingly, a balance of close and arms-length relationships can help where each relationship is developed based on its contribution rather than a singular pursuit of close relationships.

6.3 Limitations and Future Research

Supply chain performance has many dimensions. This dissertation has relied on two important measures (avoidence of termination and inventory turnover) ; however, future research may consider other measures. Each trading partner may have their own specific expectations of benefits from interfirm information exchange. As mentioned earlier in the dissertation, some qualitative information was drawn upon in order to describe more precisely the research setting. However, none of this data was used in the actual empirical testing of the hypotheses in Chapters 4 and 5. Accordingly, use of a survey tool to supplement the current objective data could provide validation of these measures as well as identification of additional performance variables. Similar studies of interfirm performance have focused on sales growth (Dyer and Singh 1998), agility (Sambamurthy et al. 2003), and innovation (Bailey et al. 2007). Including additional performance measures or a combined index of performance may recognize that firms seek performance in different aspects depending on their strategies.

A key aspect of this dissertation is its use of a unique dataset that provides objective observations of the interfirm exchange of information. Future research may incorporate subjective measures that complement these objective measures of information exchange. Supplementing the objective network data would additionally allow for the collection of additional information exchange measures. Such measures could include the use of alternate information exchange channels, experience with technologies, and the use of technology intermediaries. Additional perceived relational measures often used in relational marketing literature include trust, commitment, and long-term orientation (Ganesan 1994; Morgan and Hunt 1994).

In spite of potential areas for future research, the significance of this dissertation is still evident. The theory, methodology, empirical testing, and results have extended the supply chain management literature and addressed important gaps. In so doing, this dissertation has raised some important questions and opened up new possible research streams. As supply chains become increasingly dependent upon information exchange and information technology, this dissertation help provide insight into further investigations.

Appendix

APPENDIX A Sample ANSI X12 and EDIFACT Message Types

The following tables provide examples of standard EDI transaction types defined for business documents. Column one describes the type of information included in the business document and column two provides the code number used to identify that business document.

Table A.1 ANSI X12 Message Types and Descriptions

Description	Type
Motor Carrier Pick-up Manifest	211
Rail Waybill Request	425
Requisition	511
Project Schedule Reporting	806
Invoice	810
Remittance Advice	820
Inventory Report	846
Purchase Order	850
Purchase Order Change Request	860
Purchase Order Change Acknowledgement	865
Production Sequence	866
Order Status Inquiry	869
Grocery Products Purchase Order	875
Grocery Products Invoice	880
Item Maintenance	888
Promotion Announcement	889
Warehouse Shipping Advice	945

Table A.2 United Nations EDIFACT Message Types and Descriptions

Description	Type
Invoice	INVOIC
Purchase Order	ORDERS
Purchase Order Change	ORDCHG
Remittance Advice	REMADV
Credit Advice Message	CREADV
Data Maintenance Status Report	DMSTAT
Financial Statement of an Account Message	FINSTA
General Purpose Message	GENRAL
Extended Payment Order Message	PAYEXT
Product Data Message	PRODAT
Payment Order Message	PAYORD
Quality Data Message	QALITY
Quote Message	QUOTES
Receiving Advice	RECADV
Remittance Advice	REMADV
Sales Forecast	SLSFCT
Sales Report	SLSRPT

APPENDIX B Transactional Information Types

The following table lists all standard EDI transaction types identified in this dissertation as transactional information exchange. Column one displays the EDI transaction code and column two provides the standard description. Numeric transaction codes are from the ANSI X12 standard. Alphabetic transactions codes are from the United Nations EDIFACT standard.

Table B.1 Transactional Information EDI Types

Type	Description
107	Request for Motor Carrier Rate Proposal
110	Air Freight Details and Invoice
141	Product Service Claim Response
142	Product Service Claim
210	Motor Carrier Freight Details and Invoice
223	Consolidators Freight Bill and Invoice
310	Freight Receipt and Invoice (Ocean)
511	Requisition
810	Invoice
811	Consolidated Service Invoice Statement
812	Credit/Debit Adjustment
820	Payment Order / Remittance Advice
821	Financial Information Reporting
822	Account Analysis
823	Lockbox
827	Financial Return Notice
828	Debit Authorization
829	Payment Cancellation Request
836	Procurement Notices
838	Trading Partner Profile
840	Request for Quotation
843	Response to Request for Quotation
850	Purchase Order
855	Purchase Order Acknowledgement
857	Shipment and Billing Notice
859	Freight Invoice
860	Purchase Order Change Request - Buyer Initiated
865	Purchase Order Change Acknowledgement - Seller Initiated
869	Order Status Inquiry
870	Order Status Report
875	Grocery Products Purchase Order
880	Grocery Products Invoice
BANSTA	Banking Status Message
DIRDEB	Direct Debit Message
FINSTA	Financial Statement of an Account Messsage
INVOIC	Invoice
ORDCHG	Purchase Order Change Request Message
ORDERS	Purchase Order Message
ORDRSP	Purchase Order Response Message
OSTRPT	Order Status Report Message
PAYEXT	Extended Payment Order Message
PAYMUL	Multiple Payment Order Message
REMADV	Remittance Advice Message

APPENDIX C Enhanced Transaction Types

The following table lists all standard EDI transaction types identified in this dissertation as enhanced information exchange. Column one displays the EDI transaction code and column two provides the standard description. Numeric transaction codes are from the ANSI X12 standard. Alphabetic transactions codes are from the United Nations EDIFACT standard.

Table C.1 Enhanced Information EDI Types

Type	Description
104	Air Shipment Information
109	Vessel Content Details
140	Product Registration
180	Return Merchandise Authorization and Notification
204	Motor Carrier Load Tender
211	Motor Carrier Bill of Lading
212	Motor Carrier Delivery Trailer Manifest
213	Motor Carrier Shipment Status Inquiry
214	Transporation Carrier Shipment Status Message
215	Motor Carrier Pick-up Manifest
217	Motor Carrier Loading and Route Guide
240	Motor Carrier Package Status
300	Reservation (Ocean)
301	Confirmation (Ocean)
304	Shipping Instructions
311	Canadian Customs Information
313	Shipment Status Inquiry
315	Status Details (Ocean)
322	Terminal Operations and Intermodal Ramp Activity
404	Rail Carrier Shipment Information
418	Rail Advance Interchange Consist
440	Shipment Wieghts
501	Vendor Performance Review
527	Material Due-In and Receipt
601	U.S. Customs Export Shipment Information
753	Request for Routing Information
830	Planning Schedule with Release Capability
832	Price / Sales Catalog
841	Specifications / Technical Information
841	Specifications / Technical Information
842	Nonconformance Report
844	Product Transfer Account Adjustment
845	Price Authorization Acknowledgment / Status
846	Inventory Inquiry / Advice
848	Material Safety Data Sheet
849	Response to Product Transfer Acount Adjustment
852	Product Activity Data
853	Routing and Carrier Instruction
854	Shipment Delivery Discrepancy Information
856	Ship Notice / Manifest
858	Shipment Information
861	Receiving Advice / Accpetance Certificate
862	Shipping Schedule
863	Report of Test Results
866	Production Sequence
867	Product Transfer Resale Report
879	Price Information
882	Direct Store Delivery Summary Information
888	Item Maintenance
889	Promotion Announcement
894	Delivery / Return Base Record
940	Warehouse Shipping Order
943	Warehouse Stock Transfer Shipment Advice
944	Warehouse Stock Transfer Receipt Advice
945	Warehouse Shipping Advice
947	Warehouse Inventory Adjustment Advice
990	Response to a Load Tender
CUSDEC	Customs Declaration Message
DELFOR	Delivery Schedule Message
DELJIT	Delivery Just In Time
DESADV	Dispatch Advice Message
IFCSUM	Forwarding and Consolidation Summary Message
IFTMAN	Arrival Notice Message
IFTSTA	International Multimodal Status Message
INSDES	Instruction to Dispatch Message
INVRPT	Inventory Report Message
PRICAT	Price / Sales Catalog Message
QALITY	Quality Data Message
RECADV	Receiving Advice Message
SLSRPT	Sales Data Report Message

APPENDIX D Logistic Regression Results

The following tables provide the full logistic regression results. Column one of the table provides the variable name, column two shows the value of the coefficient estimate, column three the standard error, column four the z-score for the coefficient estimate, column five the p-value, and column six the level of statistical significance. Statistical significance is noted as ** for p<0.01, * for p<0.05, and + for p<0.1.

This Appendix includes four tables of regression results. Table D.1 provides regression results for the full dataset. Tables D.2 through D.4 provide stratified dataset results detailing the coefficient estimates when each echelon of the supply chain is regressed individually (manufacturers, wholesalers, retailers). Each table of regression results is followed by a summary of the overall model statistics.

Table D.1 Full Results of Logistic Termination Study

TERMINATION	Coef.	Std. Err	Z	P>|z|	sig
TRANSACTIONAL_VOLUME	-6.2809	0.7646	-8.22	0.0000	**
TRANSACTIONAL_VOLUME^2	0.6102	0.0764	7.98	0.0000	**
ENHANCED_VOLUME	-10.2760	2.1512	-4.78	0.0000	**
ENHANCED_VOLUME^2	3.2679	0.8111	4.03	0.0000	**
ENHANCED_TRANSACTIONAL RATIO	4.41E-06	1.98E-05	0.22	0.8240	ns
constant	-3.9163	0.1402	-27.93	0.0000	**
Control Variables					
MONTH_DUMMY1	-1.9548	0.1093	-17.89	0.0000	**
MONTH_DUMMY2	-1.4380	0.0958	-15.01	0.0000	**
MONTH_DUMMY3	-0.9738	0.0864	-11.26	0.0000	**
MONTH_DUMMY4	-0.2453	0.0758	-3.24	0.0010	*
MONTH_DUMMY5	-1.0162	0.0899	-11.31	0.0000	**
MONTH_DUMMY6	-1.4781	0.1024	-14.44	0.0000	**
MONTH_DUMMY7	-1.2878	0.0978	-13.17	0.0000	**
MONTH_DUMMY8	-1.5088	0.1050	-14.37	0.0000	**
MONTH_DUMMY9	-1.4866	0.1047	-14.19	0.0000	**
MONTH_DUMMY10	-1.4329	0.1061	-13.51	0.0000	**
MONTH_DUMMY11	-0.8034	0.0881	-9.12	0.0000	**
MONTH_DUMMY12	-0.4853	0.0838	-5.79	0.0000	**
MONTH_DUMMY13	-0.6199	0.0875	-7.09	0.0000	**
MONTH_DUMMY14	-0.5578	0.0867	-6.44	0.0000	**
MONTH_DUMMY15	-0.9474	0.0978	-9.69	0.0000	**
MONTH_DUMMY16	0.2326	0.0763	3.05	0.0020	*
MONTH_DUMMY17	-0.7576	0.0972	-7.80	0.0000	**
MONTH_DUMMY18	-0.4795	0.0902	-5.32	0.0000	**
MONTH_DUMMY19	-0.1827	0.0862	-2.12	0.0340	*
MONTH_DUMMY20	-0.8474	0.1027	-8.25	0.0000	**
MONTH_DUMMY21	0.0207	0.0828	0.25	0.8020	ns
MONTH_DUMMY22	1.0205	0.0712	14.32	0.0000	**
FIRM_DUMMY1	2.1181	0.1964	10.78	0.0000	**
FIRM_DUMMY2	0.1024	0.1794	0.57	0.5680	ns
FIRM_DUMMY3	1.0591	0.1562	6.78	0.0000	**
FIRM_DUMMY4	2.4658	0.1729	14.26	0.0000	**
FIRM_DUMMY5	0.7430	0.1515	4.90	0.0000	**
FIRM_DUMMY6	0.8048	0.3034	2.65	0.0080	*
FIRM_DUMMY7	1.6421	0.1424	11.53	0.0000	**
FIRM_DUMMY8	1.9996	0.1996	10.02	0.0000	**
FIRM_DUMMY9	0.4023	0.1556	2.58	0.0100	*
FIRM_DUMMY10	0.6752	0.2336	2.89	0.0040	*
FIRM_DUMMY11	0.1020	0.2267	0.45	0.6530	ns
FIRM_DUMMY12	3.2476	0.1493	21.75	0.0000	**
FIRM_DUMMY13	1.0706	0.1324	8.08	0.0000	**
FIRM_DUMMY14	0.4226	0.2199	1.92	0.0550	+
FIRM_DUMMY15	1.0010	0.1661	6.03	0.0000	**
FIRM_DUMMY16	1.0935	0.1571	6.96	0.0000	**
FIRM_DUMMY17	-0.1623	0.4686	-0.35	0.7290	ns
FIRM_DUMMY18	3.2401	0.1715	18.89	0.0000	**
FIRM_DUMMY19	1.1590	0.1612	7.19	0.0000	**
FIRM_DUMMY20	1.5779	0.1635	9.65	0.0000	**
FIRM_DUMMY21	1.5814	0.2020	7.83	0.0000	**
FIRM_DUMMY22	1.6268	0.1885	8.63	0.0000	**
FIRM_DUMMY23	1.3632	0.3038	4.49	0.0000	**
FIRM_DUMMY24	1.1411	0.1295	8.81	0.0000	**
FIRM_DUMMY25	0.2153	0.4321	0.50	0.6180	ns
FIRM_DUMMY26	1.7749	0.1624	10.93	0.0000	**
FIRM_DUMMY27	2.4315	0.1432	16.98	0.0000	**
FIRM_DUMMY28	-0.8318	0.1744	-4.77	0.0000	**
FIRM_DUMMY29	-0.5542	0.1769	-3.13	0.0020	*
FIRM_DUMMY30	0.1233	0.1429	0.86	0.3880	ns
FIRM_DUMMY31	0.2340	0.2595	0.90	0.3670	ns
FIRM_DUMMY32	-0.3435	0.3174	-1.08	0.2790	ns
FIRM_DUMMY33	2.1859	0.2203	9.92	0.0000	**
FIRM_DUMMY34	2.1901	0.1597	13.71	0.0000	**
FIRM_DUMMY35	0.5480	0.1355	4.04	0.0000	**
FIRM_DUMMY36	0.5393	0.1397	3.86	0.0000	**
FIRM_DUMMY37	1.4211	0.2872	4.95	0.0000	**
FIRM_DUMMY38	2.1856	0.1968	11.10	0.0000	**

Model Statistics

Observations	255,076
LR chi2	5,684
Prob>chi2	0.0000
Psuedo R2	0.0948
Log Likelihood	-27,150.29

Table D.2 Stratified Logistic Results: Manufacturers

TERMINATION	Coef.	Std. Err	Z	P>|z|	sig
TRANSACTIONAL_VOLUME	-5.7153	2.2169	-2.58	0.0100	*
TRANSACTIONAL_VOLUME^2	6.8415	2.3809	2.87	0.0040	*
ENHANCED_VOLUME	-6.8762	3.7239	-1.85	0.0650	*
ENHANCED_VOLUME^2	10.2529	12.5015	0.82	0.4120	ns
ENHANCED_TRANSACTIONAL RATIO	-2.96E-04	0.000536	-0.55	0.5800	ns
constant	-2.0442	0.1416	-14.44	0.0000	**
Control Variables					
MONTH_DUMMY1	-5.4571	0.3196	-17.07	0.0000	**
MONTH_DUMMY2	-4.9835	0.2647	-18.83	0.0000	**
MONTH_DUMMY3	-3.2939	0.1499	-21.97	0.0000	**
MONTH_DUMMY4	-4.1806	0.2058	-20.32	0.0000	**
MONTH_DUMMY5	-4.4166	0.2277	-19.40	0.0000	**
MONTH_DUMMY6	-4.0832	0.2009	-20.32	0.0000	**
MONTH_DUMMY7	-3.1121	0.1496	-20.80	0.0000	**
MONTH_DUMMY8	-4.1728	0.2143	-19.47	0.0000	**
MONTH_DUMMY9	-4.4068	0.2360	-18.67	0.0000	**
MONTH_DUMMY10	-4.4447	0.2406	-18.47	0.0000	**
MONTH_DUMMY11	-3.8019	0.1907	-19.93	0.0000	**
MONTH_DUMMY12	-3.1931	0.1587	-20.13	0.0000	**
MONTH_DUMMY13	-4.1703	0.2386	-17.48	0.0000	**
MONTH_DUMMY14	-2.7055	0.1449	-18.68	0.0000	**
MONTH_DUMMY15	-3.4377	0.1949	-17.64	0.0000	**
MONTH_DUMMY16	-2.6947	0.1529	-17.62	0.0000	**
MONTH_DUMMY17	-2.3876	0.1441	-16.57	0.0000	**
MONTH_DUMMY18	-1.6914	0.1241	-13.62	0.0000	**
MONTH_DUMMY19	-3.4607	0.2509	-13.79	0.0000	**
MONTH_DUMMY20	-3.1426	0.2178	-14.43	0.0000	**
MONTH_DUMMY21	-0.8175	0.1097	-7.45	0.0000	**
MONTH_DUMMY22	-1.9169	0.2019	-9.49	0.0000	**
FIRM_DUMMY1	--	--	--	--	--
FIRM_DUMMY2	--	--	--	--	--
FIRM_DUMMY3	2.9327	0.2058	14.25	0.0000	**
FIRM_DUMMY4	--	--	--	--	--
FIRM_DUMMY5	3.4181	0.1857	18.40	0.0000	**
FIRM_DUMMY6	0.9032	0.3125	2.89	0.0040	*
FIRM_DUMMY7	1.7586	0.1503	11.70	0.0000	**
FIRM_DUMMY8	--	--	--	--	--
FIRM_DUMMY9	2.3415	0.2142	10.93	0.0000	**
FIRM_DUMMY10	0.7357	0.2410	3.05	0.0020	*
FIRM_DUMMY11	--	--	--	--	--
FIRM_DUMMY12	--	--	--	--	--
FIRM_DUMMY13	0.1322	0.2319	0.57	0.5690	ns
FIRM_DUMMY14	--	--	--	--	--
FIRM_DUMMY15	--	--	--	--	--
FIRM_DUMMY16	0.4550	0.2258	2.01	0.0440	*
FIRM_DUMMY17	-0.2171	0.4765	-0.46	0.6490	ns
FIRM_DUMMY18	4.2632	0.1870	22.80	0.0000	**
FIRM_DUMMY19	1.2986	0.1669	7.78	0.0000	**
FIRM_DUMMY20	1.8601	0.1710	10.88	0.0000	**
FIRM_DUMMY21	--	--	--	--	--
FIRM_DUMMY22	--	--	--	--	--
FIRM_DUMMY23	--	--	--	--	--
FIRM_DUMMY24	1.8672	0.2157	8.66	0.0000	**
FIRM_DUMMY25	0.1817	0.4440	0.41	0.6820	ns
FIRM_DUMMY26	--	--	--	--	--
FIRM_DUMMY27	2.1767	0.1709	12.74	0.0000	**
FIRM_DUMMY28	--	--	--	--	--
FIRM_DUMMY29	--	--	--	--	--
FIRM_DUMMY30	-0.8822	0.1772	-4.98	0.0000	**
FIRM_DUMMY31	0.3047	0.2656	1.15	0.2510	ns
FIRM_DUMMY32	-0.3646	0.3223	-1.13	0.2580	ns
FIRM_DUMMY33	2.8559	0.2302	12.41	0.0000	**
FIRM_DUMMY34	--	--	--	--	--
FIRM_DUMMY35	--	--	--	--	--
FIRM_DUMMY36	2.8616	0.1699	16.85	0.0000	**
FIRM_DUMMY37	1.8093	0.3020	5.99	0.0000	**
FIRM_DUMMY38	3.1163	0.2068	15.07	0.0000	**

Model Statistics

Observations	51,420
LR chi2	3,169
Prob>chi2	0.0000
Psuedo R2	0.2468
Log Likelihood	-4,851.56

Table D.3 Stratified Logistic Results: Wholesalers

TERMINATION	Coef.	Std. Err	Z	P>|z|	sig
TRANSACTIONAL_VOLUME	-23.0539	4.8015	-4.8	0.0000	**
TRANSACTIONAL_VOLUME^2	2.1515	0.5459	3.94	0.0000	**
ENHANCED_VOLUME	-5.4869	4.3961	-1.25	0.2120	ns
ENHANCED_VOLUME^2	1.6330	1.7376	0.94	0.3470	ns
ENHANCED_TRANSACTIONAL RATIO	1.72E-05	1.44E-05	1.19	0.2330	ns
constant	-2.9665	0.2050	-14.47	0.0000	**
Control Variables					
MONTH_DUMMY1	-2.0382	0.4008	-5.08	0.0000	**
MONTH_DUMMY2	-2.2843	0.4497	-5.08	0.0000	**
MONTH_DUMMY3	0.2012	0.2239	0.90	0.3690	ns
MONTH_DUMMY4	-0.8873	0.2843	-3.12	0.0020	*
MONTH_DUMMY5	-1.6555	0.3679	-4.50	0.0000	**
MONTH_DUMMY6	-0.9450	0.2920	-3.24	0.0010	*
MONTH_DUMMY7	-0.8235	0.2841	-2.90	0.0040	*
MONTH_DUMMY8	-1.1341	0.3131	-3.62	0.0000	**
MONTH_DUMMY9	-0.6172	0.2714	-2.27	0.0230	*
MONTH_DUMMY10	-0.1328	0.2441	-0.54	0.5870	ns
MONTH_DUMMY11	-0.5886	0.2742	-2.15	0.0320	*
MONTH_DUMMY12	-1.0154	0.3125	-3.25	0.0010	**
MONTH_DUMMY13	-1.4678	0.3676	-3.99	0.0000	**
MONTH_DUMMY14	-1.5623	0.3824	-4.09	0.0000	**
MONTH_DUMMY15	-0.9068	0.3065	-2.96	0.0030	*
MONTH_DUMMY16	-0.2242	0.2558	-0.88	0.3810	ns
MONTH_DUMMY17	-1.1337	0.3348	-3.39	0.0010	*
MONTH_DUMMY18	-0.8981	0.3125	-2.87	0.0040	**
MONTH_DUMMY19	1.7698	0.2008	8.81	0.0000	**
MONTH_DUMMY20	0.1324	0.2495	0.53	0.5960	ns
MONTH_DUMMY21	0.1390	0.2510	0.55	0.5800	ns
MONTH_DUMMY22	-0.4283	0.2920	-1.47	0.1420	ns
FIRM_DUMMY1	--	--	--	--	--
FIRM_DUMMY2	-0.9616	0.1588	-6.06	0.0000	**
FIRM_DUMMY3	-0.0316	0.1320	-0.24	0.8110	ns
FIRM_DUMMY4	--	--	--	--	--
FIRM_DUMMY5	--	--	--	--	--
FIRM_DUMMY6	--	--	--	--	--
FIRM_DUMMY7	--	--	--	--	--
FIRM_DUMMY8	--	--	--	--	--
FIRM_DUMMY9	--	--	--	--	--
FIRM_DUMMY10	--	--	--	--	--
FIRM_DUMMY11	--	--	--	--	--
FIRM_DUMMY12	--	--	--	--	--
FIRM_DUMMY13	--	--	--	--	--
FIRM_DUMMY14	--	--	--	--	--
FIRM_DUMMY15	--	--	--	--	--
FIRM_DUMMY16	--	--	--	--	--
FIRM_DUMMY17	--	--	--	--	--
FIRM_DUMMY18	--	--	--	--	--
FIRM_DUMMY19	--	--	--	--	--
FIRM_DUMMY20	--	--	--	--	--
FIRM_DUMMY21	--	--	--	--	--
FIRM_DUMMY22	--	--	--	--	--
FIRM_DUMMY23	--	--	--	--	--
FIRM_DUMMY24	--	--	--	--	--
FIRM_DUMMY25	--	--	--	--	--
FIRM_DUMMY26	--	--	--	--	--
FIRM_DUMMY27	--	--	--	--	--
FIRM_DUMMY28	-1.6738	0.1552	-10.78	0.0000	**
FIRM_DUMMY29	--	--	--	--	--
FIRM_DUMMY30	--	--	--	--	--
FIRM_DUMMY31	--	--	--	--	--
FIRM_DUMMY32	--	--	--	--	--
FIRM_DUMMY33	--	--	--	--	--
FIRM_DUMMY34	--	--	--	--	--
FIRM_DUMMY35	-0.5798	0.1108	-5.23	0.0000	**
FIRM_DUMMY36	--	--	--	--	--
FIRM_DUMMY37	--	--	--	--	--
FIRM_DUMMY38	--	--	--	--	--

Model Statistics

Observations	43,321
LR chi2	902
Prob>chi2	0.0000
Psuedo R2	0.1265
Log Likelihood	-3,114.46

Table D.4 Stratified Logistic Results: Retailers

TERMINATION	Coef.	Std. Err	Z	P>|z|	sig
TRANSACTIONAL_VOLUME	-10.5603	1.2327	-8.57	0.0000	**
TRANSACTIONAL_VOLUME^2	3.4942	0.4076	8.57	0.0000	**
ENHANCED_VOLUME	-25.0600	5.4516	-4.6	0.0000	**
ENHANCED_VOLUME^2	15.5237	3.1330	4.95	0.0000	**
ENHANCED_TRANSACTIONAL RATIO	4.14E-05	0.0003	0.15	0.8850	ns
constant	-2.2066	0.1547	-14.27	0.0000	**
Control Variables					
MONTH_DUMMY1	-1.7880	0.1201	-14.89	0.0000	**
MONTH_DUMMY2	-1.2072	0.1046	-11.54	0.0000	**
MONTH_DUMMY3	-1.3271	0.1098	-12.09	0.0000	**
MONTH_DUMMY4	0.0004	0.0837	0.00	0.9960	
MONTH_DUMMY5	-0.7825	0.0990	-7.90	0.0000	**
MONTH_DUMMY6	-1.5111	0.1221	-12.38	0.0000	**
MONTH_DUMMY7	-1.7109	0.1319	-12.97	0.0000	**
MONTH_DUMMY8	-1.4961	0.1233	-12.14	0.0000	**
MONTH_DUMMY9	-1.5111	0.1245	-12.14	0.0000	**
MONTH_DUMMY10	-1.6169	0.1349	-11.99	0.0000	**
MONTH_DUMMY11	-0.6880	0.1000	-6.88	0.0000	**
MONTH_DUMMY12	-0.3558	0.0952	-3.74	0.0000	**
MONTH_DUMMY13	-0.3355	0.0959	-3.50	0.0000	**
MONTH_DUMMY14	-0.5487	0.1014	-5.41	0.0000	**
MONTH_DUMMY15	-0.8824	0.1135	-7.78	0.0000	**
MONTH_DUMMY16	0.4428	0.0856	5.17	0.0000	**
MONTH_DUMMY17	-1.0281	0.1269	-8.10	0.0000	**
MONTH_DUMMY18	-1.0324	0.1255	-8.23	0.0000	**
MONTH_DUMMY19	-1.2072	0.1375	-8.78	0.0000	**
MONTH_DUMMY20	-1.0290	0.1274	-8.08	0.0000	**
MONTH_DUMMY21	-0.8270	0.1202	-6.88	0.0000	**
MONTH_DUMMY22	0.8671	0.0823	10.54	0.0000	**
FIRM_DUMMY1	--	--	--	--	--
FIRM_DUMMY2	--	--	--	--	--
FIRM_DUMMY3	--	--	--	--	--
FIRM_DUMMY4	--	--	--	--	--
FIRM_DUMMY5	-0.8483	0.1618	-5.2400	0.0000	**
FIRM_DUMMY6	--	--	--	--	--
FIRM_DUMMY7	--	--	--	--	--
FIRM_DUMMY8	--	--	--	--	--
FIRM_DUMMY9	-1.1958	0.1657	-7.2200	0.0000	**
FIRM_DUMMY10	--	--	--	--	--
FIRM_DUMMY11	--	--	--	--	--
FIRM_DUMMY12	1.4977	0.1598	9.3700	0.0000	**
FIRM_DUMMY13	-0.5082	0.1441	-3.5300	0.0000	**
FIRM_DUMMY14	--	--	--	--	--
FIRM_DUMMY15	-0.5912	0.1756	-3.3700	0.0010	
FIRM_DUMMY16	--	--	--	--	--
FIRM_DUMMY17	--	--	--	--	--
FIRM_DUMMY18	--	--	--	--	--
FIRM_DUMMY19	--	--	--	--	--
FIRM_DUMMY20	--	--	--	--	--
FIRM_DUMMY21	--	--	--	--	--
FIRM_DUMMY22	--	--	--	--	--
FIRM_DUMMY23	-0.2683	0.3092	-0.8700	0.3860	
FIRM_DUMMY24	-0.4889	0.1413	-3.4600	0.0010	
FIRM_DUMMY25	--	--	--	--	--
FIRM_DUMMY26	--	--	--	--	--
FIRM_DUMMY27	0.6439	0.1539	4.1800	0.0000	**
FIRM_DUMMY28	--	--	--	--	--
FIRM_DUMMY29	--	--	--	--	--
FIRM_DUMMY30	-1.4896	0.1538	-9.6900	0.0000	**
FIRM_DUMMY31	--	--	--	--	--
FIRM_DUMMY32	--	--	--	--	--
FIRM_DUMMY33	--	--	--	--	--
FIRM_DUMMY34	--	--	--	--	--
FIRM_DUMMY35	-1.0844	0.1469	-7.38	0.0000	**
FIRM_DUMMY36	--	--	--	--	--
FIRM_DUMMY37	--	--	--	--	--
FIRM_DUMMY38	--	--	--	--	--

Model Statistics

Observations	160,335
LR chi2	3,523
Prob>chi2	0.0000
Psuedo R2	0.0886
Log Likelihood	-18,130.01

APPENDIX E Hazard Model Results

The following tables provide the full Cox Proportional Hazards Model results. The tables are formatted as described in Appendix D. This appendix includes four tables of results. Table E.1 provides regression results for the full dataset. Tables E.2 through E.4 provide stratified dataset results detailing the coefficient estimates when each echelon of the supply chain is regressed individually (manufacturers, wholesalers, retailers). Each table of regression results is followed by a summary of the overall model statistics.

Table E.1 Full Hazard Model Results

TERMINATION	Coef.	Std. Err	Z	P>|z|	sig
TRANSACTIONAL_VOLUME	-9.7162	0.8996	-10.80	0.0000	**
TRANSACTIONAL_VOLUME^2	0.9230	0.0877	10.53	0.0000	**
ENHANCED_VOLUME	-17.5925	2.5864	-6.80	0.0000	**
ENHANCED_VOLUME^2	5.5218	0.9024	6.12	0.0000	**
ENHANCED_TRANSACTIONAL RATIO	8.43E-06	1.87E-05	0.45	0.6510	ns
Control Variables					
FIRM_DUMMY1	2.6801	0.1909	14.04	0.0000	**
FIRM_DUMMY2	0.1610	0.1776	0.91	0.3650	ns
FIRM_DUMMY3	1.1573	0.1540	7.51	0.0000	**
FIRM_DUMMY4	3.2461	0.1684	19.28	0.0000	**
FIRM_DUMMY5	0.8390	0.1497	5.61	0.0000	**
FIRM_DUMMY6	0.8967	0.2981	3.01	0.0030	*
FIRM_DUMMY7	1.8111	0.1404	12.90	0.0000	**
FIRM_DUMMY8	2.2715	0.1943	11.69	0.0000	**
FIRM_DUMMY9	0.4247	0.1539	2.76	0.0060	*
FIRM_DUMMY10	0.7200	0.2300	3.13	0.0020	*
FIRM_DUMMY11	0.1540	0.2244	0.69	0.4930	ns
FIRM_DUMMY12	4.3805	0.1452	30.17	0.0000	**
FIRM_DUMMY13	1.1625	0.1310	8.87	0.0000	**
FIRM_DUMMY14	0.4473	0.2171	2.06	0.0390	*
FIRM_DUMMY15	1.0853	0.1637	6.63	0.0000	**
FIRM_DUMMY16	1.1711	0.1547	7.57	0.0000	**
FIRM_DUMMY17	-0.0991	0.4647	-0.21	0.8310	ns
FIRM_DUMMY18	4.2302	0.1644	25.73	0.0000	**
FIRM_DUMMY19	1.2230	0.1585	7.71	0.0000	**
FIRM_DUMMY20	1.7141	0.1603	10.69	0.0000	**
FIRM_DUMMY21	1.8070	0.1974	9.16	0.0000	**
FIRM_DUMMY22	1.6454	0.1837	8.96	0.0000	**
FIRM_DUMMY23	1.4555	0.2955	4.93	0.0000	**
FIRM_DUMMY24	1.2282	0.1281	9.58	0.0000	**
FIRM_DUMMY25	0.2680	0.4273	0.63	0.5310	ns
FIRM_DUMMY26	1.9740	0.1593	12.39	0.0000	**
FIRM_DUMMY27	3.1201	0.1407	22.18	0.0000	**
FIRM_DUMMY28	-0.8274	0.1732	-4.78	0.0000	**
FIRM_DUMMY29	-0.5375	0.1755	-3.06	0.0020	*
FIRM_DUMMY30	0.1311	0.1415	0.93	0.3540	ns
FIRM_DUMMY31	0.2916	0.2567	1.14	0.2560	ns
FIRM_DUMMY32	-0.3518	0.3150	-1.12	0.2640	ns
FIRM_DUMMY33	2.6658	0.2131	12.51	0.0000	**
FIRM_DUMMY34	2.6980	0.1563	17.26	0.0000	**
FIRM_DUMMY35	0.5511	0.1341	4.11	0.0000	**
FIRM_DUMMY36	0.6300	0.1383	4.56	0.0000	**
FIRM_DUMMY37	1.6061	0.2800	5.74	0.0000	**
FIRM_DUMMY38	2.8559	0.1910	14.95	0.0000	**

Model Statistics

Observations	255,076
LR chi2	5,027
Prob>chi2	0.0000
Log Likelihood	-69,576.74

Table E.2 Stratified Hazard Model Results: Manufacturers

TERMINATION	Coef.	Std. Err	Z	P>|z|	sig
TRANSACTIONAL_VOLUME	-7.2445	2.2283	-3.25	0.0010	*
TRANSACTIONAL_VOLUME^2	7.2641	2.1074	3.45	0.0010	*
ENHANCED_VOLUME	-9.0192	3.4302	-2.63	0.0090	*
ENHANCED_VOLUME^2	16.2170	9.8837	1.64	0.1010	ns
ENHANCED_TRANSACTIONAL RATIO	-3.77E-04	0.000531	-0.71	0.4770	ns
Control Variables					
FIRM_DUMMY1	3.7529	0.1988	18.88	0.0000	**
FIRM_DUMMY2	--	--	--	--	--
FIRM_DUMMY3	--	--	--	--	--
FIRM_DUMMY4	4.5169	0.1810	24.95	0.0000	**
FIRM_DUMMY5	--	--	--	--	--
FIRM_DUMMY6	0.8887	0.2965	3.00	0.0030	*
FIRM_DUMMY7	1.9408	0.1433	13.54	0.0000	**
FIRM_DUMMY8	2.7067	0.2016	13.42	0.0000	**
FIRM_DUMMY9	--	--	--	--	--
FIRM_DUMMY10	0.7311	0.2301	3.18	0.0010	*
FIRM_DUMMY11	0.1571	0.2250	0.70	0.4850	ns
FIRM_DUMMY12	--	--	--	--	--
FIRM_DUMMY13	--	--	--	--	--
FIRM_DUMMY14	0.4488	0.2173	2.07	0.0390	*
FIRM_DUMMY15	--	--	--	--	--
FIRM_DUMMY16	--	--	--	--	--
FIRM_DUMMY17	-0.1504	0.4651	-0.32	0.7460	ns
FIRM_DUMMY18	5.5959	0.1800	31.09	0.0000	**
FIRM_DUMMY19	1.2202	0.1587	7.69	0.0000	**
FIRM_DUMMY20	1.9859	0.1610	12.33	0.0000	**
FIRM_DUMMY21	1.8074	0.2003	9.02	0.0000	**
FIRM_DUMMY22	--	--	--	--	--
FIRM_DUMMY23	--	--	--	--	--
FIRM_DUMMY24	--	--	--	--	--
FIRM_DUMMY25	0.2353	0.4278	0.55	0.5820	ns
FIRM_DUMMY26	2.5102	0.1628	15.42	0.0000	**
FIRM_DUMMY27	--	--	--	--	--
FIRM_DUMMY28	-0.8495	0.1734	-4.90	0.0000	**
FIRM_DUMMY29	--	--	--	--	--
FIRM_DUMMY30	--	--	--	--	--
FIRM_DUMMY31	0.3429	0.2567	1.34	0.1820	ns
FIRM_DUMMY32	-0.3482	0.3150	-1.11	0.2690	ns
FIRM_DUMMY33	3.6088	0.2186	16.51	0.0000	**
FIRM_DUMMY34	3.6377	0.1639	22.20	0.0000	**
FIRM_DUMMY35	--	--	--	--	--
FIRM_DUMMY36	--	--	--	--	--
FIRM_DUMMY37	1.8328	0.2806	6.53	0.0000	**
FIRM_DUMMY38	4.0153	0.2002	20.06	0.0000	**

Model Statistics

Observations	51,420
LR chi2	2,636
Prob>chi2	0.0000
Log Likelihood	-11,757.96

Table E.3 Stratified Hazard Model Results: Wholesalers

TERMINATION	Coef.	Std. Err	Z	P>|z|	sig
TRANSACTIONAL_VOLUME	-34.7517	5.4582	-6.37	0.0000	**
TRANSACTIONAL_VOLUME^2	3.2472	0.5900	5.50	0.0000	**
ENHANCED_VOLUME	-8.7122	5.2078	-1.67	0.0940	+
ENHANCED_VOLUME^2	2.6181	1.8341	1.43	0.1530	ns
ENHANCED_TRANSACTIONAL RATIO	2.33E-05	1.49E-05	1.56	0.1190	ns
Control Variables					
FIRM_DUMMY1	--	--	--	--	--
FIRM_DUMMY2	-0.9459	0.1547	-6.11	0.0000	**
FIRM_DUMMY3	0.0500	0.1269	0.39	0.6930	ns
FIRM_DUMMY4	--	--	--	--	--
FIRM_DUMMY5	--	--	--	--	--
FIRM_DUMMY6	--	--	--	--	--
FIRM_DUMMY7	--	--	--	--	--
FIRM_DUMMY8	--	--	--	--	--
FIRM_DUMMY9	--	--	--	--	--
FIRM_DUMMY10	--	--	--	--	--
FIRM_DUMMY11	--	--	--	--	--
FIRM_DUMMY12	--	--	--	--	--
FIRM_DUMMY13	--	--	--	--	--
FIRM_DUMMY14	--	--	--	--	--
FIRM_DUMMY15	--	--	--	--	--
FIRM_DUMMY16	--	--	--	--	--
FIRM_DUMMY17	--	--	--	--	--
FIRM_DUMMY18	--	--	--	--	--
FIRM_DUMMY19	--	--	--	--	--
FIRM_DUMMY20	--	--	--	--	--
FIRM_DUMMY21	--	--	--	--	--
FIRM_DUMMY22	--	--	--	--	--
FIRM_DUMMY23	--	--	--	--	--
FIRM_DUMMY24	--	--	--	--	--
FIRM_DUMMY25	--	--	--	--	--
FIRM_DUMMY26	--	--	--	--	--
FIRM_DUMMY27	--	--	--	--	--
FIRM_DUMMY28	-1.6967	0.1517	-11.18	0.0000	**
FIRM_DUMMY29	--	--	--	--	--
FIRM_DUMMY30	--	--	--	--	--
FIRM_DUMMY31	--	--	--	--	--
FIRM_DUMMY32	--	--	--	--	--
FIRM_DUMMY33	--	--	--	--	--
FIRM_DUMMY34	--	--	--	--	--
FIRM_DUMMY35	-0.5020	0.1070	-4.69	0.0000	**
FIRM_DUMMY36	--	--	--	--	--
FIRM_DUMMY37	--	--	--	--	--
FIRM_DUMMY38	--	--	--	--	--

Model Statistics

Observations	43,321
LR chi2	329
Prob>chi2	0.0000
Log Likelihood	-6,419.96

Table E.4 Stratified Hazard Model Results: Retailers

TERMINATION	Coef.	Std. Err	Z	P>|z|	sig
TRANSACTIONAL_VOLUME	-15.0735	1.4312	-10.53	0.0000	**
TRANSACTIONAL_VOLUME^2	4.5713	0.4082	11.20	0.0000	**
ENHANCED_VOLUME	-51.6863	7.4789	-6.91	0.0000	**
ENHANCED_VOLUME^2	30.8093	4.1358	7.45	0.0000	**
ENHANCED_TRANSACTIONAL RATIO	1.67E-04	0.000321	0.52	0.6030	ns
Control Variables					
FIRM_DUMMY1	--	--	--	--	--
FIRM_DUMMY2	--	--	--	--	--
FIRM_DUMMY3	--	--	--	--	--
FIRM_DUMMY4	--	--	--	--	--
FIRM_DUMMY5	-0.7456	0.1563	-4.7700	0.0000	**
FIRM_DUMMY6	--	--	--	--	--
FIRM_DUMMY7	--	--	--	--	--
FIRM_DUMMY8	--	--	--	--	--
FIRM_DUMMY9	-1.1698	0.1604	-7.2900	0.0000	
FIRM_DUMMY10	--	--	--	--	--
FIRM_DUMMY11	--	--	--	--	--
FIRM_DUMMY12	2.5306	0.1520	16.6500	0.0000	**
FIRM_DUMMY13	-0.4184	0.1386	-3.0200	0.0030	*
FIRM_DUMMY14	--	--	--	--	--
FIRM_DUMMY15	-0.5060	0.1697	-2.9800	0.0030	*
FIRM_DUMMY16	--	--	--	--	--
FIRM_DUMMY17	--	--	--	--	--
FIRM_DUMMY18	--	--	--	--	--
FIRM_DUMMY19	--	--	--	--	--
FIRM_DUMMY20	--	--	--	--	--
FIRM_DUMMY21	--	--	--	--	--
FIRM_DUMMY22	--	--	--	--	--
FIRM_DUMMY23	-0.1775	0.2989	-0.5900	0.5530	ns
FIRM_DUMMY24	-0.3869	0.1358	-2.8500	0.0040	*
FIRM_DUMMY25	--	--	--	--	--
FIRM_DUMMY26	--	--	--	--	--
FIRM_DUMMY27	1.2830	0.1475	8.7000	0.0000	**
FIRM_DUMMY28	--	--	--	--	--
FIRM_DUMMY29	--	--	--	--	--
FIRM_DUMMY30	-1.4972	0.1484	-10.0900	0.0000	**
FIRM_DUMMY31	--	--	--	--	--
FIRM_DUMMY32	--	--	--	--	--
FIRM_DUMMY33	--	--	--	--	--
FIRM_DUMMY34	--	--	--	--	--
FIRM_DUMMY35	-1.1059	0.1413	-7.82	0.0000	**
FIRM_DUMMY36	--	--	--	--	--
FIRM_DUMMY37	--	--	--	--	--
FIRM_DUMMY38	--	--	--	--	--

Model Statistics

Observations	160,335
LR chi2	2,549
Prob>chi2	0.0000
Log Likelihood	45,616.05

APPENDIX F Calculating Sales Surprise

This study evaluates two standard forecasting methods based on historical data to calculate the sales surprise. Although alternative forecasting methods are available, the two methods selected provide robust forecasts for evaluation and are commonly used in practice.

A moving average forecast uses actual data values from prior periods to generate a forecast. A moving average forecast is generated using the following equation:

$$\hat{F}_t = MA_n = \frac{\sum_{i=1}^{n} A_{t-i}}{n} = \frac{A_{t-n} + \ldots\ldots + A_{t-2} + A_{t-1}}{n} \qquad [F.1]$$

Where $\hat{F}_t$ is the forecast for time period t , MA_n identifies the number of periods included in the moving average window, A_{t-1} is the actual value in period $t-1$, and n is the number of data points in the moving average (Stevenson 2007). The moving average forecast can include as many data points as desired; however, since it is averaging or smoothing the historic values increasing the number of data points decreases the responsiveness of the forecast to recent changes. Similarly, decreasing the number of data points increases the sensitivity of the forecast to recent changes. Moving average forecasts are popular in practice but require the decision maker to determine the appropriate number of periods to include in the forecast. For the purposes of this study, moving average forecasts were calculated for all firms based on the inclusion of two, four, and eight periods.

Exponential smoothing (also called Single Smoothing or noted "SS") is a more sophisticated averaging forecast method which can incorporate large amounts of historic data points while placing emphasis on the more recent events. The exponential smoothing forecast adds a percentage of the difference between the prior period forecast and the actual value observed during the prior period. An exponential smoothing forecast is generated using the following equation:

$$\hat{F}_t = \hat{F}_{t-1} + \alpha\left(\mathrm{A}_{\mathrm{t-1}} - \hat{F}_{t-1}\right) \qquad [\text{F.2}]$$

Where F_t is the forecast for period t, $\hat{F}_{t-1}$ is the forecast for the prior period, α is a smoothing constant, and A_{t-1} is the actual value observed during the prior period (Stevenson 2007; Tersine 1993). This forecast method is generated over time, such that the forecasts and forecasting error in each of the previous periods are incorporated into the current forecast, the model is more generally stated as:

$$\hat{F}_t = \alpha\sum_{k=1}^{t}(1-\alpha)^{k-1}A_{t-k} + (1-\alpha)^{\mathrm{t}}\,\hat{F}_0 \qquad [\text{F.3}]$$

Where $\hat{F}_t$ is the forecasted demand level for period t, $\hat{F}_0$ is the forecasted demand level for the initial period, and A_{t-1} is the actual demand for period $t-1$. The smoothing constant represented by α incorporates a percentage of the previous forecast error into the new forecast. The responsiveness of the forecast is then driven by the magnitude of the smoothing constant. The closer the smoothing constant is to zero, the slower the forecast will adjust for forecasting error in the prior period. A smoothing constant closer to 1.00 will be very responsive to recent forecast error.

In practice, the smoothing constant is selected based on judgment of the decision maker or trial and error. Smoothing constants commonly range from 0.05 to 0.50 depending on the underlying demand behavior and business responsiveness needs. For the purposes of this study, smoothing constants of 0.05, 0.25, and 0.50 were used to estimate forecasts for all firms. Results of these forecasts will be discussed at the end of this section.

Since the exponential smoothing forecast uses the historic period error to calculate the current forecast, a starting forecast must be identified. An average of the first several periods is often used to generate the starting forecast (Stevenson 2007). For the purposes of this study, a moving average forecast based on the four quarters of 2003 was used to generate a starting forecast for first quarter of 2004. The exponential smoothing forecast was then run starting in first quarter (Q1 2004) through the next seven periods to the end of the study (Q4 2005).

The resulting six forecasts (MA_2, MA_4, MA_8, $SS_{\alpha=0.05}$, $SS_{\alpha=0.25}$, $SS_{\alpha=0.50}$) are then compared to identify the best fit for estimating sales. A key measure used to select forecast methods is forecast accuracy (Stevenson 2007). Forecast accuracy is operationalized as the difference between the actual observed value during a period and the forecasted value for the period (error).

$$e_t = A_t - \hat{F}_t \qquad [F.4]$$

Where e_t is the forecasting error for period t based on the difference between the actual observed value for the period (A_t) and the forecast for the period ($\hat{F}_t$). A larger value of error indicates greater inaccuracy in the forecast. Positive error then is the result of a forecast that was too low, negative error is the result of a forecast that was too high relative to the actual observed value for the period.

Forecast error is aggregated using one of two standard measures. The two measures are; the mean squared error (MSE) and mean absolute deviation (MAD).

$$MAD = \frac{\sum |e|}{n} \qquad [\text{F.5}]$$

$$MSE = \frac{\sum e^2}{n} \qquad [\text{F.6}]$$

The MAD is the average absolute difference between the forecast and observed values for each period-firm combination. By using the absolute value of the difference, the canceling effects of negative and positive error are eliminated. Similarly, the MSE method eliminates the canceling effects of positive and negative error by squaring the period-firm error. The difference in the two methods is that the MAD treats all error equally where the MSE weights the errors based on their squared values. In either case, lower aggregate results identify less error in the forecasting method (Stevenson 2007).

As shown in Table F.1, the moving average methods produce lower error than the exponential smoothing methods. The lowest overall error is produced by the moving average 4-period and moving average 4-period specifications. This holds for both the mean squared error and mean absolute deviation methods of calculating forecast error.

TABLE F.1 Forecast Accuracy by Forecast Method

Forecast Method	Mean Squared Error	Mean Absolute Deviation
Moving Average - 2 Periods	262,994,910	170,127
Moving Average - 4 Periods	211,310,507	156,971
Moving Average - 8 Periods	351,056,626	210,372
Exponential Smoothing α=0.05	648,074,453	274,312
Exponential Smoothing α=0.25	1,436,286,821	371,650
Exponential Smoothing α=0.50	4,312,283,372	547,632

For the purposes of this study, moving average 4-period is used to calculate the firm-period forecasted sales, which is used in deriving the per-period sales surprise.

APPENDIX G Alternative Dependent Variable Results

The following tables provide model fit statistics and coefficient estimates for two alternative model specifications. Table G.1 provides output for the alternative Net Income dependent variable. Table G.2 provides output for the alternative Receivables Turnover dependent variable. Table G.3 includes the pairwise correlations for the primary dependent variable (INVENTORY_TURNOVER) and both alternative dependent variables.

TABLE G.1 Alternative Dependent Variable: Net Income

n		170
groups		39
R-square	within	0.2036
	between	0.5991
	overall	0.4371
F		3.12
Prob>F		0.0014

(log)NET_INCOME	Coef. (Std Err)	P>| t |	sig
Explanatory Variables			
(log)CLOSE	0.5085 (0.2819)	0.074	+
(log)ASYMMETRY	-0.2039 (0.1342)	0.131	ns
(log)CONCENTRATION	0.1429 (0.3047)	0.640	ns
(log)CHURN_RATE	-0.0917 (0.0949)	0.336	ns
constant	25.8130 (10.5323)	0.016	*
Control Variables			
(log)FIRMSIZE	-2.3305 (1.1113)	0.038)	*
(log)SALES_SURPRISE	2.7638 (0.6295)	0.000	**
(log)NET_INCOME_LAG	0.0004 (0.0976)	0.997	ns
SEASON1DUMMY	0.5500 (0.2019)	0.007	*
SEASON2DUMMY	0.2888 (0.1767)	0.105	ns
SEASON3DUMMY	0.3513 (0.1760)	0.048	*

**<.01 *<.05 +<.1 significance level

TABLE G.2 Alternative Dependent Variable: Receivables Turnover

n		184
groups		37
R-square	within	0.7541
	between	0.9849
	overall	0.9840
F		42.02
Prob>F		0.0000

(log)RECEIVABLES_TURN	Coef. (Std Err)	P>| t |	sig
Explanatory Variables			
(log)CLOSE	-0.0188 (0.0127)	0.143	ns
(log)ASYMMETRY	0.0151 (0.0065)	0.022	ns
(log)CONCENTRATION	0.00003 (0.0149)	0.998	ns
(log)CHURN_RATE	0.0001 (0.0049)	0.979	ns
constant	-0.1247 (0.5191)	0.811	ns
Control Variables			
(log)FIRMSIZE	0.0792 (0.0511)	0.123	ns
(log)SALES_SURPRISE	0.0548 (0.0254)	0.033	*
(log)REC_TURN_LAG	0.7409 (0.0373)	0.000	**
SEASON1DUMMY	-0.0027 (0.0098)	0.781	ns
SEASON2DUMMY	0.0074 (0.0084)	0.382	ns
SEASON3DUMMY	0.0014 (0.5191)	0.811	ns

**<.01 *<.05 +<.1 significance level

TABLE G.3 Correlation Matrix for Alternative Dependent Variables

	INVENTORY_ TURNOVER	NET_INCOME	RECEIVABLES_ TURN
INVENTORY_TURNOVER	1 302		
NET_INCOME	0.0868 0.1322 302	1 310	
RECEIVABLES_TURN	-0.0783 0.1866 286	***-0.1871*** ***0.0013*** ***294***	1 294

statistically significant pairwise correlations are highlighted in bold and italics

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