WHEN DO FIRMS USE INTERNET-ENABLED REVERSE AUCTIONS? THE ROLE OF ASSET SPECIFICITY, PRODUCT SPECIALIZATION, AND NON-CONTRACTIBILITY

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ABSTRACT

IT-enabled exchange in electronic markets has significant implications for buyer-supplier relationships. Building on previous research that emphasizes the role of intangible assets in inter-organizational relationships, this study argues that buyers are less likely to use reverse auctions for supplier relationships involving a high degree of non-contractibility, complementing traditional transaction cost economics arguments that focus on the impact of asset specificity and product specialization. We identify and operationalize six dimensions of non-contractibility: quality, supplier technological investments, information exchange, responsiveness, trust, and flexibility. The results show that non-contractible elements of an inter-organizational relationship strongly influence buyers’ use of reverse auctions. This study provides evidence for the importance of supplier investments in non-contractible elements of exchange relationships to affect buyer loyalty in an increasingly competitive economy.

Keywords: Reverse Auctions, Electronic Markets, Transaction cost economics, Inter-organizational relationships, Incomplete Contracts Approach.
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1.0 INTRODUCTION

Internet based business-to-business (B2B) electronic markets have become increasingly common across industries in the past few years. Although these markets no longer enjoy as much publicity as they did before the dot-com decline, many firms now use electronic markets as integral parts of their procurement and sourcing strategies. At the same time, though, many electronic B2B markets have failed. Extensive recent academic work in electronic markets has examined electronic commerce in the business-to-consumer (B2C) context (Ba and Pavlou 2002; Bapna, Goes, Gupta and Jin 2004; Pavlou and Gefen 2004; Wood 2004). By contrast, despite the potential economic importance of B2B electronic markets, little academic research has attempted to develop and test a framework to understand buyers’ use – or lack of use – of different types of electronic markets (Gebauer and Buxmann 2000).

This paper examines buyer firms’ use of reverse auctions, one of the prominent types of B2B electronic markets. Reverse auctions raise important questions that require theory development and testing. A major theme in sourcing and supply management for the last two decades has been to reduce the number of suppliers in order to develop long term relationship with a few suppliers (Bensaou 1997; Steinfield, Kraut and Plummer 1995), in response to the growing importance of knowledge-based exchanges in the emerging hypercompetitive service economy (Grover, Teng and Fiedler 2002; Sambamurthy, Bharadwaj and Grover 2003). Although use of reverse auction promises cost saving potential (Elmaghraby 2004; Jap 2002), buyers face a dilemma in switching from traditional supply relationships to electronic reverse auctions because using such markets imperils their relationships with existing suppliers (Dai and Kauffman 2001; Hart and Saunders 1998; Pinker, Seidmann and Vakrat 2003). Indeed, some observers have suggested lack of attention to relational aspects in sourcing as one of the main reasons for the failures of many electronic markets.

This paper assesses the relative impact of three factors that may influence firms’ use of reverse auctions: asset specificity, product specialization, and non-contractibility. We develop a theoretical model that draws on transaction cost economics (Williamson 1975). We build on previous work by
Malone, Yates and Benjamin (1987) that argues that asset-specificity and product specialization will have significant influence on use of reverse auctions by buyers. Asset specificity involves assets that require customized and relatively non-redeployable physical and human capital investments (Williamson 1985), while product specialization refers to the nature of the product in terms of ease of description. We extend this work by considering the role of non-contractible factors to explain the use of reverse auctions (Bakos and Brynjolfsson 1993a; Bakos and Brynjolfsson 1998; Clemons, Reddi and Row 1993; Clemons and Row 1992). Non-contractible factors are product or supplier characteristics that will influence future exchanges and that buyers can observe but that third parties, such as courts, cannot easily verify; such factors are difficult to specify in contracts. Related research argues that quality, technological investments, information exchange, responsiveness, trust, and flexibility are important non-contractible factors in a buyer-supplier relationship (Bakos and Brynjolfsson 1993a; Bakos and Brynjolfsson 1993b).

We undertook a field study of reverse auction use by U.S. automotive assemblers and component manufacturers. The study included discussions with executives to shape the theoretical model and provide contextual details, followed by a detailed survey of firms in the industry. The study finds that asset specificity, product specialization, and non-contractibility influence reverse auction use. We also find that non-contractibility has greater explanatory power compared to the traditional notion of asset specificity in explaining reverse auction use, consistent with incomplete contracts arguments.

2.0 THEORY AND HYPOTHESES

Our goal in this study is to gain a theoretical understanding of when firms use reverse auctions. This section briefly reviews relevant prior literature on the use of inter-organizational systems. We then develop hypotheses that assess how asset specificity, product specialization, and non-contractibility will influence the use of reverse auctions.

2.1 Literature

Rapid improvements in functionality coupled with dramatic decline in cost of IT in the last three decades have sparked significant research activity to understand the transformational effect of IT (Agarwal and Lucas 2005; Sambamurthy, Bharadwaj and Grover 2003). Researchers have used
transaction cost economics (Gurbaxani and Whang 1991; Malone, Yates and Benjamin 1987),
information processing (Bensaou and Venkatraman 1995), and agency theory (Gurbaxani and Whang
1991) to study interorganizational systems and buyer-supplier relationships. Much of the theorizing in
this domain of research pertains to the effect of IT on the coordination of tasks (Gurbaxani and Whang
1991), firm size (Brynjolfsson, Malone, Gurbaxani and Kambil 1994), and firm boundaries (Gurbaxani

The transaction costs economics (TCE) literature provides a particularly useful theoretical lens to
begin an assessment of trends in governance structure. TCE argues that firm boundaries are determined
by a trade-off between production cost advantages of outside procurement in market relationships and the
transaction cost advantages of internal production within hierarchies (Ang and Straub 1998; Grover,
Cheon and Teng 1996; Williamson 1975). Markets and hierarchies entail different levels of production
and transaction costs. Markets may offer lower production costs because of economies of scale or
specialization, but these advantages come at the expense of higher transaction costs. Transaction costs
arise because of dedicated investment in specialized assets. Environmental uncertainty, bounded
rationality of economic agents, and partners’ potential for opportunistic behavior lead firms to employ a
variety of safeguards to protect their specialized investments (Williamson 1985). These safeguards range
from formal mechanisms such as financial or specialized investment hostages (Klein and Leffler 1981) to
informal mechanisms such as relational trust and reputation (Dyer 1997).

Information systems researchers have used the TCE perspective to argue that growing use of
information technology will affect the mechanisms that firms use to govern their inter-firm relationships.
Malone, Yates and Benjamin (1987) were among the first scholars to recognize the role of IT on the
coordination of tasks and firm boundaries. Their conceptual work made two predictions: a general
reduction in coordination costs enabled by IT, and a move toward greater use of markets compared to
hierarchy. Subsequent work proceeded along three directions: (1) empirical testing of TCE predictions,
(2) extension and enrichment of TCE reasoning and (3) application of TCE and complementary
perspectives to explain the use and effect of interorganizational systems.
One line of enquiry focuses on testing the implications of early conceptual work (Gurbaxani and Whang 1991; Malone, Yates and Benjamin 1987). The empirical findings have been mixed. Some studies found evidence consistent with the predictions of the “electronic market hypothesis” (EMH), which expected greater use of market relationships. For example, Brynjolfsson et al. (1994) tested the prediction that IT would lead to lower coordination costs, and found that IT investments are significantly associated with a subsequent decrease in the average size of firms. Hitt (1999) reported that use of IT is associated with a decrease in vertical integration and an increase in diversification. Dewan et al. (1998) suggest that IT has had greater effect on reducing costs of external coordination, rather than in reducing costs of internal coordination within a firm. However, other studies have found less support for the EMH. Hess and Kemerer (1994) tested the “move to market” corollary of the electronic market hypothesis in the home mortgage industry, but found limited support for the EMH based on their analysis of five case studies. Choudhury, Hartzel and Konsynski (1998) report that the EMH does not fully explain use of electronic markets in the aircraft parts industry and note the need for considering “additional variables …in understanding the uses and impacts of electronic markets” (p. 471).

A second line of work has focused on extending the reasoning and typology of market-hierarchy that Malone et al. (1987) proposed, by considering the importance of inter-organizational relationships. Grover et al. (2002) and Christiaanse and Markus (2002) argued that TCE arguments implicit in the EMH do not fully address the preexisting and extended nature of supply chain relationships, which leads to under-emphasizing relational benefits. Other researchers have proposed several nuances to the original typology of markets and hierarchies. For example, using the information processing view, Bensaou and Venkatraman (1995) found several types of inter-organizational relationships that U.S. and Japanese automakers use in order to fit their information processing needs to their information processing capabilities. Information processing needs depend on environmental, partnership, and task uncertainty, while information processing capabilities derive from three inter-organizational coordination mechanisms: structural, process, and information technology. Their research implies that firms can select among several alternative mechanisms in matching their information processing needs with information
processing capabilities. Choudhury (1997) extended the market-hierarchy typology and classified inter-organizational systems into electronic dyads, multilateral inter-organizational information systems, and electronic monopolies. He mapped this typology to the three strategies that firms use in acquiring a product: sole source, relational market exchange, and spot market exchange. In a parallel work, Holland and Lockett (1997) proposes a typology of mixed mode network structures ranging from hierarchy to market that differ on market complexity, asset specificity, coordination strategy, inter-organizational systems, and network structure. More recently, Chatterjee and Watson (2005) have proposed a typology of twelve electronic partnering options. They argue that relational risks in a relationship determine whether an electronic partnership will be tightly or loosely coupled and conducted over a public or a private network.

In turn, a third line of enquiry focuses on the design, use, and effect of inter-organizational systems (Chatterjee and Ravichandran 2004 summarize this work). Bensaou (1997) found that relational characteristics are more robust predictors of buyer-supplier cooperation than traditional asset specificity. Bensaou and Anderson (1999) study the conditions under which buyers make supplier specific idiosyncratic investments. They argue that such specific investments improve coordination for complex products, reduce buyer risk against technological uncertainty, and help buyers cope with thin supply markets (i.e., rather than treat asset specificity as a cause of organizational choices, they study how investment in specific assets will influence organizational activities). Choudhury et al. (1998) find that electronic markets had statistically insignificant impact on prices in the aircraft industry particularly for parts for which quality was important. Hart and Saunders (1998) and Subramani and colleagues (2004; 2003) study conditions under which suppliers are likely to use EDI systems and benefit from such use.

small and fixed set of suppliers and award deals to specific suppliers using a RFQ based bidding process. Although case studies provide important insights in the early stages of enquiry about a phenomenon, they need to be complemented with large scale studies to test the generalizability of the phenomenon (Singleton and Straits 2005). Some researchers have conducted large scale surveys in the context of inter-organizational systems (Monczka, Peterson and Handfield 1998; Subramani 2004; Subramani and Venkatraman 2003), but these studies focus on electronic data interchange (EDI) systems that rely on proprietary networks and applications rather than internet-based open systems.

To our knowledge, ours is the first large scale empirical study that explains use of Internet-enabled reverse auctions in a commercial setting. The study tests both relational and traditional transaction cost perspectives in predicting the use of an important type of electronic market.

Whether one views the discussion of inter-organizational relationships as an alternative to transaction cost theory or an extension of the theory depends on how encompassing a view of TCE theory that one wishes to take. We do not take a strong stand on just where the dividing line lies in demarking TCE explanations from “other” explanations. Instead, our primary purpose here is to highlight the importance of inter-organizational issues such as non-contractibility, which have not been fully reflected in prior studies of electronic markets or, more generally, of firm boundaries.

This research also has practical implications. Buyers need to choose products and services that are the best candidates for procurement through use of reverse auctions. Although reverse auctions offer potential cost savings and reduced risk of hold-up, they also threaten the sensitive nature of collaborative relationships with an existing supplier base. Our study provides insights that help in deciding which products and services are most suitable for procurement through reverse auctions.

### 2.2 A Theoretical Model for Explaining Buyers’ Use of Reverse Auctions

As we noted earlier, the EMH suggests that information technology reduces transaction costs because flexible manufacturing technology reduces investment in specific assets, facilitates product description, and reduces communication and information processing costs (Malone, Yates and Benjamin 1987). Although this argument recognizes that electronic hierarchies might be desirable when asset
specificity is high, the principal prediction is that information technology will cause increased use of market outsourcing. Malone et al. (1987) suggest that “electronic hierarchies frequently develop into biased, then unbiased markets when the products themselves are not asset specific and are easily described in standardized terms (p. 495).” They also note that “in the long run, the significant additional benefits to buyers possible from the electronic brokerage effect will drive almost all electronic markets toward being unbiased channels for products from many suppliers (p. 491).” The basic premise of the EMH is that information technology will reduce transaction costs, both because of reduction in specialized investment in production assets and because of greater ease of inter-firm communication, which in turn would lead to greater reliance on arm’s length relationships with many suppliers. An implication of the EMH argument, therefore, is that buyer-supplier relationships that require general investments, involving little asset specificity, will suit reverse auctions, while relationships that require substantial asset specificity will not.

Based on this TCE based reasoning, we posit that buyers are less likely to use reverse auctions for exchange relationships involving a higher degree of asset specificity. Although TCE has already been tested across multiple settings, we posit this as a baseline hypothesis to determine if this prediction holds in the context of reverse auctions.

Hypothesis 1. The greater the asset specificity in an exchange relationship, the less likely that buyers will use reverse auctions in electronic markets.

Malone et al. (1987) also identified product specialization as an important explanatory variable determining governance choice. Product specialization refers to the amount of information needed to fully specify attributes, which is sometimes referred to as description complexity. Specialized products typically require more detailed product description than commodities. As Malone et al. (1987) note: “…commodities… have simple, standardized descriptions, while those of business insurance policies or large and complicated computer systems are much more complex” (p. 486). The EMH posits that buyers will tend to procure components with lower description complexity through market-like arrangements. Clemons et al. (1993) lend support to this argument and argue that search benefits decline as products become more complex and service intensive. Choudhury, Hartzel and Konsynski (1998) concur with this
reasoning and suggest that sellers can compare commodities based on price information, while specialized products require a comparison along several additional dimensions. Specialized products with greater description complexity require joint action and call for tighter coordination mechanisms, while commodity components with relatively less description complexity are more amenable to simpler coordination mechanisms (Bensaou and Anderson 1999). We posit that buyers are less likely to use reverse auctions in exchange relationships involving greater product specialization.

Hypothesis 2. The greater the product specialization in an exchange relationship, the less likely that buyers will use reverse auctions in electronic markets.

Although asset specificity and product specialization are important, they are not sufficient to explain use of reverse auctions. Other salient factors relate to the non-contractible elements of inter-organizational exchanges. Previous research speaks to the importance of non-contractibility in influencing inter-firm relationships. Clemons, Reddi and Row (1993) argue that other considerations such as transactional economies of scale, reduced benefits of search for differentiated products, and incentives to suppliers to invest in non-contractible aspects of the relationship influence governance choices for buyer-supplier relationships. Clemons et al. (1993) agree with the overall prediction of EMH that information technology will lead to a contraction in firm boundaries, but they argue that the contraction would encourage firms to move toward long-term relationships with a smaller set of suppliers, rather than arms length relationships with many suppliers. The authors referred to such a combination of greater outsourcing but with a reduced supplier base as the move to the middle hypothesis (MMH).

Analytical work by Bakos and Brynjolfsson (1993a; 1993b), which draws on property rights and incomplete contract theory (Grossman and Hart 1986; Hart and Moore 1990; Hart 1988), provides support for the MMH. The incomplete contracts approach posits that if a buyer and a supplier can not specify all the contingencies in a contract, then their ex ante investments in the exchange relationship will be influenced by their ex post bargaining power. Under such a situation, if supplier investments in non-contractible parameters of a relationship are critical for the success of the exchange relationship then the buyer is better off by limiting its options to close relationships with a small number of suppliers. Bakos and Brynjolfsson (1993a; 1993b) suggest that tightly-coupled operations supported by IT require
increased investments by suppliers in non-contractible resources that support the relationships with buyers. Suppliers will invest more in non-contractible aspects of relationships if buyers restrict their options ex-ante by committing to specific suppliers. We posit that buyers are less likely to use reverse auctions in exchange relationships involving higher degrees of non-contractibility.

Hypothesis 3. The greater the non-contractibility in an exchange relationship, the less likely that buyers will use reverse auctions in electronic markets.

One might argue that non-contractability, rather than offering a new perspective on when firms will use reverse auctions and, more generally, how firms establish boundaries, is simply another form of asset specificity. We sympathize with this point of view, because many of the elements of non-contractability involve activities that have their greatest value in the context of a particular relationship, as we describe in greater depth in the next section. Indeed, Malone et al. (1987) point directly to the fact that asset specificity can arise over time as the result of interaction between parties. Nonetheless, a critical difference between non-contractability and traditional views of asset specificity is that specificity is a characteristic of investment in an asset that supports a particular transaction or series of stable transactions, while non-contractibility is a characteristic of investment in activities that involve a series of changing transactions between organizations over time. The major distinction is that the concept of asset specificity involves particular physical or human capital investments that a firm expects to undertake in order to support a given stream of transactions, while non-contractibility involves unknown investments that a firm may need to make in the future in order to sustain the transactions or to initiate a new set of exchanges with the partner. Therefore, although asset specificity and non-contractibility are related concepts, they warrant separate attention.

2.3 Multi-Dimensional Attributes of Non-Contractibility

Before moving to the empirical setting, we develop the notion of non-contractibility further, treating it as a multi-dimensional concept. We draw on related prior research to identify non-contractible relationship characteristics that are common in many settings. We focus on six non-contractible characteristics: quality, technological investments by a supplier, information exchange, responsiveness, trust, and flexibility. Bakos and Brynjolfsson (1993a) specifically state that quality, responsiveness,
innovation and technology adoption, trust and information exchanges “involve investments by suppliers that are difficult or impossible to specify in advance in a contract, in other words they are ‘noncontractible,’ … (p. 305).” Additionally, in a parallel work, Bakos and Brynjolfsson (1993b) note that the shift to fewer suppliers is driven by “the advantages that smaller, tighter networks of suppliers enjoy in noncontractible characteristics such as innovation, adoption of new technology, quality, information exchange, trust, flexibility, and responsiveness (p. 43).” Table 1 shows the definitions of the six dimensions of non-contractibility, with references to previous research.

Although one can analyze how each dimension of non-contractibility separately affects partner behavior in an exchange relationship, both for conceptual clarity and parsimony of the research model, we posit a categorization of non-contractibility that begins with two related sub-dimensions of “task” and “interaction.” The sub-dimensions of task and interaction appear implicitly in previous research as “task” and “process” factors. For example, Kayworth, Chatterjee, and Sambamurthy (2001) note that “given the complex nature of today’s organizations, the ability to take action may be extremely difficult and require high levels of integration of tasks and processes across a potentially wide range of organizational stakeholders” (p. 9, emphasis added). The “task” dimension of non-contractibility is important for ensuring high product performance standards, while the “interaction” dimension is important for relationship longevity. We view quality, technology investments, and information exchange as task elements of the exchange relationship. In parallel, we view responsiveness, trust, and flexibility as interaction elements of non-contractibility. Thus, we posit non-contractibility as a second order latent construct that contains two sub-dimensions, task and interaction. In turn, six first order characteristics of non-contractibility reflect the task and interaction sub-dimensions. We outline the conceptual background of the first order elements of non-contractibility here and validate their measurement in the empirical section.

**Quality.** Quality is a non-contractible aspect of a buyer-supplier relationship because quality typically encompasses attributes that satisfy customers’ unstated needs, including needs that may emerge in the future. While contracts can easily specify some quality attributes, such as tolerances and defect
rates, many other attributes – particularly those relating to fit or relative customization for a specific buyer – typically remain unstated because of difficulty in specifying them ex-ante. This is because subjective assessments of how performance of a part affects other parts and risks due to failure in meeting quality requirement are much more difficult to specify compared to standards or tolerance-based definitions of quality. Even for a commodity product such as steel, buyers often prefer a particular steel plant that may not have made investments into assets specific to a particular buyer for this reason, even though product specifications that competing steel plants offer may be the same (Deming 1993: 140). Recent work by Mayer, Nickerson and Owan (2004) makes the connection between high quality and non-contractibility explicit by arguing that: “the buyer may have a valuable reputation for a high quality product and its reputation with consumers or regulators (if the product or production is regulated) could be devalued should an undetected low-quality input enter the manufacturing process and lead to the selling of low quality output. Such spillover costs are referred to in the quality literature as external costs…spillover costs are vexing to a buyer because they are nonverifiable and thus noncontractible” (p. 1065). Given that specifying all desired quality parameters is costly and in some cases impossible (Barzel 1982), buyers are less likely to use reverse auctions to chose suppliers when quality is critical for the performance of the end product.

**Technological Investment.** Buyers competing on innovation and newer technologies need to develop partnerships with selected suppliers. Such partnerships encourage suppliers to support ongoing innovation and adopt newer technologies. Helper (1991) conducted a survey of supplier relations in the US and Japan, and found that the presence of long term contracts was a significant determinant of adoption of technologies such as CAD/CAM and CNC machines. She argued that “higher levels of information sharing and commitment…encourage suppliers to make investments that… enable them to improve performance in …product and process innovation” (p. 17). These investments need not be made specifically for a particular buyer, but instead reflect a supplier’s orientation toward use of new technology. Since use of newer technologies and willingness to support innovation are discretionary investments by suppliers, technological investments are non-contractible to the extent that contracts
cannot specify these nonspecific and discretionary investments ex-ante.

**Information Exchange.** The need to exchange information as markets, products, and processes change is often a non-contractible feature of buyer-supplier relationships. The ability to adapt products and sourcing arrangements depends on the ability of buyers and suppliers to share tacit knowledge in production tasks (Grant 1996, p. 377), which in turn benefits from hierarchy or long-term supplier relationships. Continuity of association facilitates sharing tacit knowledge because accumulating firm-specific and person-specific information causes emergence of “one single organization specific dialect” (Monteverde 1995, p.1629). Kogut and Zander (1992) note that long term relationships facilitate transactions within a supplier network via a learned and shared code. Helper (1991), Takeishi (2001), and Rai, et al. (2006) have argued that increased communication and integrated problem solving are important for improving design quality and overall performance. It is difficult to specify the exchange of specific contextual knowledge and to mandate and enforce all the desirable information exchanges in a contract, making such information exchanges a non-contractible parameter of a buyer-supplier relationship.

**Responsiveness.** The increasing demand for responsiveness to meet changing customer expectations and address heightened competition has led firms to evolve specialized governance mechanisms that resemble neither market nor hierarchy arrangements. Johnston and Lawrence (1988) provide a rich description of such hybrid mechanisms, defining value-adding partnerships as a set of independent companies that work closely together to manage the flow of goods and services along the entire value-added chain. Value-adding partnerships arise as hybrid governance mechanisms between markets and hierarchies. Each of the companies in a value-adding partnership has an incentive to stay in touch with environmental changes and be ready to react quickly, because otherwise it could lose business to other producers. Responsiveness influences governance mechanisms because each player in the value-added chain has a stake in the others’ success. This success in turn requires the ability of a unit to tailor aspects of its organization, such as personnel, plant, compensation schemes, career tracks, accounting systems and management styles, to the task at hand. The ability of a supplier firm to customize its production and delivery systems for a customer helps the buyer reap the positive aspects and avoid the
negative impact of markets and hierarchies. Milgrom and Roberts (1990) note that advances in manufacturing and distribution now allow suppliers to undertake some degree of customization without having to invest in assets specific to a particular buyer. Since responsiveness has a dynamic and contextual meaning, it is costly to specify the level of responsiveness for each contingency in a contract, thereby giving it a non-contractible character.

**Trust.** Trust is a non-contractible attribute of a relationship (Bakos and Brynjolfsson 1993a). Moorman et al. (1992) define trust as “the willingness to rely on an exchange partner in whom one has confidence.” Sabel (1993) also defines trust as the mutual confidence that no party to an exchange will exploit another’s vulnerabilities. Trust facilitates coordination, particularly as products and processes change over time (Barzel 1982; Dyer 1997: 548; Gulati, Nohira and Zaheer 2000: 209). Researchers distinguish between deterrence and knowledge-based trust (Gulati 1995; Kale, Singh and Perlmutter 2000), where knowledge-based trust is non-contractible. Several studies confirm the role of trust and coordination in cooperative relationships (Monczka, Peterson and Handfield 1998; Smith, Carroll and Ashford 1995). Barney and Hansen (1994) have argued that trust can be a source of competitive advantage for firms. Buyers will be reluctant to replace trusted suppliers, given that trust building occurs over a period of time and involves substantial costs.

**Flexibility.** Flexibility refers to the ability of a partner to adjust its behavior or the terms of an agreement to respond to changes in the environment or to the needs of its partners (Heide and John 1992). Although the concept of flexibility has some overlap with the notion of responsiveness, previous research suggests that responsiveness arises as an operational issue while flexibility relates more to the strategic aspects of a relationship (Goodhue and Thompson 1995; Monczka, Peterson and Handfield 1998). Flexibility is a non-contractible parameter because it is a reaction to unexpected situations that are not enumerated in the contract. Given the bounded rationality of partners, the viability of a relationship may depend on the flexibility with which partners can modify and go beyond the terms of the contract for continued value creation. Conner and Prahalad (1996) suggest that the flexibility with which one can change responsibilities on an ongoing basis, in order to respond to new learning or other unexpected
situations, may determine the choice of organizational mode. In their view, hierarchies offer greater flexibility compared to markets because an employment contract need not be renegotiated to alter the duties of an employee. Conner and Prahalad (1996, p.488) also argue that the cost of implementing flexibility under a market contract is higher than under firm organization, such that “firm organization is more likely to be preferred on knowledge-based flexibility grounds, the more dynamic and uncertain is the competitive environment.” We extend this reasoning to governance structure of outsourcing relationships and argue that buyers valuing flexible suppliers are less likely to risk entering new contracts instead of negotiating more favorable contracts with their existing suppliers.

3.0 RESEARCH METHODOLOGY

3.1 Research Setting

The U.S. automotive industry, with a market size of about $600 billion, is an appropriate setting to examine the use of reverse auctions because of the variation in the type of components and firm characteristics within the industry. Over the past decades, U.S. based automakers have lost market share to Japanese producers. One reason for the success of Japanese automakers is a close partnership between these automakers and their suppliers (Martin, Swaminathan and Mitchell 1998). In response, U.S. based automakers moved towards closer relationships with their suppliers, leading to consolidation within the supply chain (Cusumano and Takeishi 1991; Mudambi and Helper 1998). Supplier consolidation has helped forge closer relationships between OEMs and their suppliers, particularly through use of information technologies such as EDI. However, many suppliers stayed outside collaborative networks because of the significant set up costs and commitment that EDI technology required.

Against this backdrop of supply chain consolidation, newly emerging internet-based electronic markets pose serious questions for purchasing executives. The flexibility of newer technologies allows interconnections with a much larger global supply base promising competition induced savings. However, indiscriminate use of such technologies might nullify efforts to consolidate the supply chain as well as cancel any gains that accrue by dealing with a smaller set of more familiar incumbent suppliers.

The unit of analysis in this research is the buyer-supplier relationship for products involving
varying degrees of asset specificity, product specialization, and non-contractibility. We obtained data from business units that make independent procurement decisions. Because reverse auctions are a recent phenomenon, our analysis requires interviews and surveys of managers, rather than archival data. Following initial interviews, we collected the data through a survey of U.S. based automotive assemblers and component manufacturers.

Survey development proceeded in four phases. First, several faculty members, doctoral students, industry executives, and survey methods consultants reviewed the questionnaire for content, wording, and understandability. Wherever applicable, we used existing measurement items to develop constructs, modifying them for the context of this study. Early in the conceptual development of the study, one of the authors worked with a tier-one automotive component manufacturer in developing their reverse auctions strategy. Interactions with purchasing executives and reverse auctions vendors during the engagement helped ensure the face validity of the items we developed. Second, we refined the questionnaire based on feedback received from our interactions with industry executives and automotive industry researchers during a major industry conference in August 2001. Third, we pre-tested the refined version of the instrument from phase two with a random sample of thirty suppliers selected from an automobile industry database. Fourth, after incorporating changes based on the responses in the pretest, we administered our instrument to firms in the automotive sector during the winter of 2002.

3.2 Variables

**Likelihood of reverse auction use**: Each respondent firm rated the likelihood of using reverse auctions for two categories of production goods (commodity and specialized types of production goods) with varying degrees of asset specificity and non-contractibility. We defined production goods as items that buyers use directly in manufacturing their end products. Each respondent evaluated the likelihood of using reverse auctions on a 1 to 7 scale (1=low likelihood, 7=high likelihood).

**Asset specificity**: We measured asset specificity with a five-item scale: equipment (Dyer 1997; Mudambi and Helper 1998), labor skills (Walker and Poppo 1991), business processes (Zaheer and Venkatraman 1994), product customization (Bensaou and Anderson 1999), and JIT requirements.
Non-contractibility: We developed a new scale to assess the non-contractibility items that we described in the previous section, because the concept has received little empirical attention. In developing our scale, we relied on prior conceptual descriptions and empirical measures of elements of non-contractibility (see Table 1). We verified the content validity of the items through expert appraisals and discussions with key informants from buyers, suppliers, and electronic marketplace organizations. Later, we describe the convergent and discriminant validity of the items and constructs.

The non-contractibility measure included six multi-item constructs. Quality contains three items: manufacturing quality of the product, the extent to which a product affects performance of other parts, and the risk a product poses in terms of warranty liabilities. Technological investment contains three items: the need that a supplier stays abreast of technological developments, the need for continuous production innovation, and the degree to which a supplier develops new technology products critical to buyer success. Information exchange contains four items: the need for exchange of buyer’s proprietary information related to products, the need for supplier’s proprietary information, the need for detailed information on cost structure, and the need for buyer participation in supplier’s planning and goal setting activities. Responsiveness contains three items: supplier’s proactive anticipation of buyer needs, supplier’s responsiveness to buyer requests, and the need for a supplier to keep the buyer updated on its requests. Trust contains three items: trustworthiness, honoring past promises, and mutual confidence (previous research has operationalized trust in multiple ways; we focused on three common items in order to keep the questionnaire to a reasonable length). Flexibility contains three items: the willingness of the supplier to modify the contract, to make necessary adjustments on a continuous basis, and to go beyond the terms of a contract in fulfilling buyer needs.

Product specialization: We assessed product specialization by asking our respondents to assess one commodity and one specialty production good when they responded to our survey. As noted before, each respondent firm rated the likelihood of using reverse auctions for two categories of production goods (commodity and specialized types of production goods) with varying degrees of asset specificity and non-contractibility. Examples of commodity production goods are forgings, castings, steel, copper, and plastic.
resin; examples of specialized production goods are engineering applied polymers, engineered mold
plastics, injection molded parts, and specialty chemicals.

**Control variables:** We used four control variables to address alternative explanations for the use
of reverse auctions. Eight items measured *Information System Compatibility*, by examining investments
in legacy EDI technologies and current web technologies (Grover 1993; Mishra, Konana and Barua
2001). We controlled for information system compatibility because previous research suggests that firms
with greater information system sophistication are more likely to use newer technologies such as reverse
auctions (Grover 1993). Two items measured a firm’s *Supply Chain Strategy* in terms of buyer
orientation: a relational orientation emphasizes developing long-term relationships with major suppliers
(Grover 1993), while a transactional approach emphasizes frequent change of suppliers to gain the better
prices. We assessed the *Competitive Strategy* of a firm by measuring the extent to which the firm
emphasizes competing on cost or differentiation (Porter and Millar 1985). Firms competing on
differentiation may be less likely to use reverse auctions. Finally, we measured *Firm Size* based on annual
sales revenues, because larger firms are more likely to have a critical mass of procurement business.
Large firms are also likely to have the expertise necessary for using a licensed copy of reverse auction
software or for affording the auctioneer fees for setting up the auction. Firm size becomes an important
variable because our field interviews suggest that for most firms, reverse auction is not a one time event.

**3.3 Sample and Data Collection**

We used a list of automotive industry firms operating in the U.S. from the ELM database (2001),
a compilation of more than fourteen hundred automotive assemblers and component manufacturers. Of
those firms, seven hundred and six met our sampling criterion of more than $10 million sales annually,
including assemblers and tier-one through tier-four component manufacturers. We mailed the surveys
during the winter of 2002 in two waves. The survey package included the questionnaire, a cover letter
explaining the purpose of the study and seeking the cooperation of participants, a one-dollar bill as a
token of appreciation for the respondent’s time and effort in filling up the survey, and a return envelope.
We assured confidentiality and promised that we would report only aggregate results in any publication
(Phillips 1981). We sent two follow-up reminders, two weeks and four weeks after the first mailing.

To minimize key informant bias, we administered the surveys to the key executive responsible for the purchasing function for the firms in our sample. Such executives have a vantage point for providing relevant data and are likely to be the most knowledgeable informants (Bagozzi and Phillips 1982). This approach for relying on a single most knowledgeable informant is consistent with the practice of previous studies (Zaheer and Venkatraman 1994). We received responses from senior executives (typical designations were President, Senior Vice President, Vice-President, Director, and Manager) responsible for purchasing, materials, or procurement. Because reverse auctions were generating excitement when we sent the survey and many firms were thinking about participation in such auctions, the survey respondents could knowledgeably assess the questions relating to the use of reverse auctions in their firms.

We received 152 responses. This response rate (22%) is reasonable and comparable to previous empirical studies using survey questionnaires of firm activities (Grover, Cheon and Teng 1994; Grover, Teng and Fiedler 2002). Table 2 shows the characteristics of the respondent firms in terms of firm type (OEM v. component manufacturer), annual sales, and number of employees. There was a reasonable distribution of firm types among the respondents, with about 20% having OEM activities and the remaining being distributed among four tiers of component manufacturers (most in the first and second tiers). There also was a reasonable size distribution; about 60% had sales of less than $100 million or fewer than 500 employees, while the remainder ranged up to more than $1 billion in sales and more than 5,000 employees. In addition, 76% of the respondents were American-owned firms, while 24% had Japanese ownership. Several automotive firms in our sample had made significant use of reverse auctions and procured millions of dollars worth of production goods using such auctions.

We examined the data to assess potential issues related to non-response bias, common method bias, merging of samples from two waves of survey administration, reliability, and validity. To check for the non-response bias, we compared number of employees and annual sales for the respondents and non-respondents. We did not find any statistically significant differences, suggesting that respondent firms form a representative sample of automotive firms in the US. We limited the risk that common methods
bias might arise from respondents' concerns about social desirability and/or their implicit theories about
the phenomenon by assuring our respondent of the anonymity of their response and by the fact the many
of our predicted relationships are non-obvious at the level of individual items. We also used Harman's
one-factor test, which involves entering all the independent and dependent variable items into a factor
analysis (Podsakoff and Organ 1986). The principal component factor analysis of all measurement items
yielded several factors with eigen value exceeding one, accounting for 68 percent of the variance, while
the factor with the greatest eigen value accounted for 27 percent of the variance. Since no single factor
emerged as a dominant factor accounting for most of the variance, common method variance is unlikely
to be a serious problem in the data.

We conducted a non-parametric Kolmogorov-Smirnov two-sample test on the dependent variable
to check for any systematic bias in the wave 1 and wave 2 responses. A non-significant result implies that
one can treat data from two survey waves as arising from the same population. The Kolmogorov-Smirnov
test is more general than the two-sample t-test because it does not impose distributional assumptions. We
merged the data obtained from the two waves of the survey because we found no evidence of any
systematic difference between the two samples.

4.0 RESULTS

We used structural equation modeling to test our hypotheses. Structural models bring together
psychometric and econometric analyses in the same framework. Structural models permit us to model
unobserved constructs and the measurement error associated with our variables explicitly. We used Lisrel
version 8.52 for estimating measurement and structural models. Following the two-step approach that
Anderson and Gerbing (1988) recommend, we first present the measurement model of the structural
equation and then discuss estimates from alternative models that test our hypotheses.

4.1 Measurement Model: Reliability and Validity of Constructs

Using multiple-item scales to measure latent constructs makes it necessary to assess the validity
and reliability of scales (Anderson and Gerbing 1988). We base content validity on the selection of survey
items based on past research, our fieldwork, and discussions with industry executives and researchers, as
well as pre-testing of the instrument. To assess the reliability of the scale, we calculated composite reliability for each of the multiple item constructs (Appendix 1 shows the constructs and related items, Table 3 provides composite reliability estimates) and found these to be equal to or greater than the generally recommended value of 0.70 and well above the 0.60 threshold appropriate for newly developed scales (Nunnally 1988; Nunnally and Bernstein 1994).

Researchers have observed the difficulty in fitting structural models with a large number of items per latent variable (Williams and Hazer 1986). Bagozzi and Heatherton (1994) note that as the number of parameters and items increases, the model “can be unwieldy because of likely high levels of random error in typical items and the many parameters that must be estimated” (p. 43). Given the large number of manifest variables and complexity of our research model, we adopted a partial aggregation approach for consolidating the manifest items of a latent variable into a smaller number of composite indicators (Bagozzi and Heatherton 1994). To construct a composite indicator for each sub-construct, we used the average score of the constituent manifest items corresponding to that sub-construct. This approach reduced the number of indicator variables for non-contractibility and reverse auction use to six and seven from the nineteen and twenty-four original manifest items. We used single composite indicators for information system compatibility, competitive strategy, and supply chain strategy.

Table 3 reports the measurement model for non-contractibility, asset specificity, and reverse auction use, while Table 4 reports the correlations between constructs. Table 3 reports the factor loadings and composite reliability for latent constructs. This measurement model evaluates the reliability and validity of constructs, based on a confirmatory factor analysis framework. As Figure 1 describes, we re-specified the measurement models by combining the first-order sub-dimensions of non-contractibility and reverse auction to form second-order constructs for the two concepts. This aggregation made the research model more parsimonious and also provided better fit properties (owing to moderate correlation among the sub-dimensions of the two second-order constructs).

********** Figure 1 about here **********

We conducted the confirmatory factor analysis by pooling the items for all the constructs within
one measurement model. The measurement model suggests that the measures satisfied the requirements of reliability and validity. As Table 3 shows, the significance of factor loadings for the effect indicators provides support for convergent validity of the respective scales. The overall measurement model provided an acceptable fit (Chi-square= 509.70, df=181, RMSEA=0.077, GFI=0.87, NFI=0.92, NNFI=0.93, CFI=0.95).

We assessed discriminant validity among latent constructs by comparing an unconstrained model to models that constrained the pair-wise correlation among constructs to one (Anderson and Gerbing 1988). The discriminant analysis reveals distinct latent constructs for asset specificity, non-contractibility, and reverse auction use. Support for discriminant validity ensures that multi-collinearity does not determine parameter estimates. Note that multi-collinearity, if present, inflates the standard errors of parameter estimates, making statistically significant results more conservative (Greene 2000).

4.2 Structural Models

Table 5 presents the structural models. Before focusing on individual paths, we evaluate the measures related to overall fit of the models. The models have reasonable values of absolute fit indices. All the models have values of normed chi-squared (chi-squared/df) less than five, suggesting a reasonable fit. The Goodness of Fit Index (GFI), which is an analogue of R-squared in multiple regression, indicates that the co-variances implied by our models explain more than 80% of observed covariance in data. Since absolute fit indices such as normed chi-squared or GFI are susceptible to sample size and model complexity, we considered measures that are less susceptible to sample size. The Normed Fit Index (NFI) indicates the proportion in the improvement of the overall fit of the research model relative to a null model that assumes no correlation among observed variables. Our model yields a NFI value equal to or greater than 0.90, suggesting that the proposed models are 90% better than a null model estimated with the same sample data. The values for both the GFI and NFI indicate that the models have adequate overall fit, as do NNFI, CFI, RMSEA, and AIC measures that Table 5 reports (Bollen 1989; Kline 1998).

We build the models sequentially. Models 1 and 2 alternate the asset specificity and non-contractibility variables. We take this approach owing to the substantial correlation between the two
variables ($r=0.74$), so that we want to check for the individual influences before turning to the joint influences in Model 3 (despite the correlation, recall that discriminant validity tests demonstrated separation of the asset specificity and non-contractibility measures). Model 3 then reports the full model.

The results in Table 5 provide the strongest support for influences from specialization and non-contractibility. The initial results in model 1 offer moderate support for H1, concerning asset specificity ($\beta_{11} = -0.21, p<.10$), but the significance disappears when we add non-contractibility to the analysis in model 3, in which asset specificity is insignificant ($\beta_{31} = 0.20, \text{n.s.}$). The results unambiguously support H2, as all three models report a significant negative influence of specialization ($\beta_{32} = -0.63, p<0.01$ in model 3). Models 2 and 3 both support H3, reporting a significant negative influence of non-contractibility ($\beta_{33} = -0.44, p<0.01$ in model 3).

Although the results in model 3, the full model, provide stronger support for non-contractibility than for the measure of asset specificity, we need to be careful in assessing this comparison owing to the correlation between the two variables. Therefore, we also compared the overall fit of models 1 and 2, as a complementary means of assessing the relative impact of the two variables. A statistical comparison of models 1 and 2 provides a useful perspective on judging the relative strengths of asset specificity and non-contractibility. Because models 1 and 2 are non-nested, it is not possible to use a likelihood ratio test for comparing the relative superiority of models. Therefore, we compare models 1 and 2 with the Akaike Information Criterion (AIC), which is a Bayesian fit statistic. The lower value of the AIC for model 2 compared to the AIC for model 1 indicates that model 2 has a better fit (Gill 2002), which suggests that non-contractibility has greater explanatory power compared to asset specificity in predicting the use of reverse auctions. Because there are no guidelines based on AIC for preferring one model over another, we computed BIC statistics for models 1 and 2 based on Raftery’s (1996) discussion of comparing non-nested models within a Bayesian framework. We find a difference of more than 10 in the BIC statistic between models 1 and model 2, again lending support for model 2 compared to model 1.

Finally, we undertook exploratory analysis in which we estimated model 3 with the two first-order sub-dimensions of task and interaction non-contractibility, rather than the aggregate second-order
construct of non-contractibility. We find results that are consistent with those that we report in Table 3. Whether we introduce task and interaction non-contractibility alone or jointly, asset specificity is not significant, consistent with the reported results. This result is particularly reassuring, because the two sub-dimensions of non-contractibility have only moderate correlation with asset specificity (r=0.49 between asset specificity and task-based non-contractibility; r=0.69 between asset specificity and interaction-based non-contractibility). Of the two sub-dimensions of non-contractibility, task-based non-contractibility has the greatest impact on reverse auction use.

The core results have three implications. First, buyers prefer to avoid reverse auctions for specialized goods. This result extends previous research. For example, Bensaou (1999), in his study of 447 managers across U.S. and Japanese automakers, found that components in market-exchange have much lower average product complexity compared to components in captive buyer, captive supplier and strategic partnership exchange. Although Choudhury and colleagues (Choudhury 1997; Choudhury, Hartzel and Konsynski 1998) did not find support for the effect of product complexity on the use of electronic markets in the aircraft parts industry, they cautioned extending their findings to other electronic markets because their study considered an electronic market that had only supplier identification functionality. In contrast, the scope of reverse auctions in our study includes supplier selection as well.

Second, buyers avoid reverse auctions when relationships with suppliers will involve substantial non-contractible commitments. This result reinforces the argument that inter-organizational relational requirements has substantial influence on the nature of exchange relationships (Bakos and Brynjolfsson 1993a; Bakos and Brynjolfsson 1993b; Christiaanse and Markus 2002; Clemons, Reddi and Row 1993; Grover, Teng and Fiedler 2002; Heiman and Nickerson 2002).

Third, buyers tend to avoid reverse auctions when components involve substantial asset specificity, but primarily to the extent that the asset specificity also reflects non-contractible commitments (i.e., once non-contractibility is assessed directly, asset specificity does not have a significant influence on reverse auction use). The lack of significance of the asset specificity measure in model 3 does not mean that asset specificity is irrelevant in reverse auctions but, instead, does suggest that the most important
aspects of asset specificity are those that are reflected in the non-contractible elements of a relationship. To a real extent, this point reinforces thoughtful discussions in prior transaction cost analyses that point out that specialized investments do not arise simply from physical investment or from investment around a single stream of transactions but commonly arise from relational interactions that involve two or more parties (e.g., Malone et al., 1987). Non-contractibility will be particularly prevalent when such interactions involve a complex and changing set of activities over time.

As we noted earlier, we are sympathetic to the argument that non-contractibility reflects an aspect of the transaction cost argument. However, this is an aspect that is sometimes underemphasized and, indeed, may often have the biggest impact on boundary choices in cases such as our reverse auctions context. We note that our measure of asset specificity does not restrict itself purely to physical investment, but also includes investments in human assets and business processes. The key distinction remains, though, that the concept of asset specificity speaks most directly to particular investments that a firm expects to undertake in order to support a specified stream of transactions, while non-contractibility speaks more directly to unknown investments that a firm may need to make in the future in order to sustain the transactions or to initiate a new set of exchanges with the partner.

The control variables in Table 5 also provide useful insights. First, buyers with a relationship orientation to supply chain strategy are less likely to adopt reverse auctions compared to buyers that take a transaction orientation towards their suppliers. This result provides further credence to relational arguments. Second, larger firms are more likely to use reverse auctions. Larger firms might have scale that justifies undertaking a new form of procurement (including paying the auctioneer fees for setting up the auction) or, alternatively, may possess expertise needed to use a licensed copy of reverse auction software; further research could usefully tease out these alternatives. Third, the positive coefficient of information system compatibility in models 1 and 2 initially implies that buyers are more likely to adopt reverse auctions if they have a compatible information system infrastructure in place. This is a meaningful finding because our results show that use of reverse auctions is more than just buying an off the shelf reverse auction or engaging the services of a third party auctioneer such as Freemarkets. Firms
with greater IT capability and better experience in using IT in supply chain processes may be more likely to use reverse auctions. However, the fact that the effect becomes insignificant in model 3 suggests that assessing the degree of non-contractibility may dominate the independent effect of system compatibility, suggesting caution in using this result to guide strategy. Finally, the nature of competitive strategy (differentiation versus cost leadership) does not have a significant effect on reverse auction use, which suggests that the nature of a particular component and relationship dominate any general tendencies that a buyer may have in orienting its strategy.

4.3 Exploratory Analyses

Table 6 presents exploratory analyses to assess the robustness of our primary findings. A buyer’s perception of the non-contractible investments that its suppliers make might correlate with the buyer’s satisfaction with its suppliers. If so, then buyers may be less likely to auction business for which suppliers have high satisfaction ratings. We used three items to assess buyers’ satisfaction with current suppliers. The items explore the extent to which current supplier performance influences the decision to use reverse auctions suppliers (Dai and Kauffman 2000; Helper 1991).

The results reject the argument that buyers avoid reverse auctions if they are satisfied with current suppliers. As Table 6 shows, comparison of items a and b indicates that buyers are likely to use reverse auctions even if they are satisfied with their incumbent suppliers. This result indicates that buyers will not limit their use of reverse auctions only to those situations in which they are dissatisfied with their incumbent suppliers. The difference between items a and b is significant at $p < 0.05$ (Panel B).

Nonetheless, incumbent suppliers do not necessarily lose due to increased competition because buyers often reward loyal suppliers by continuing business even if they do not provide the lowest bids in the auction process (row c of Table 6, Panel A). Supplier loyalty often involves investment in non-contractible factors that support buyer relationships. Thus, satisfaction with suppliers’ non-contractible investments increases buyers’ switching costs and makes such suppliers less vulnerable compared to suppliers with which buyers are less satisfied. Follow-up interviews with an electronic market service provider and a large buyer revealed that incumbents commonly enjoy a 3%-6% relationship premium:
buyers often set reverse auction reservation prices below current prices by about this percentage range.

To assess the robustness of the structural equation models, we also estimated OLS and ordered probit models. Because some researchers consider the assumptions about correlations among error terms of manifest items that structural equation modeling requires to be somewhat restrictive (Freedman 1997), estimating complementary models helps triangulate the results using a within-study design (Singleton and Straits; (Kulp, Lee and Ofek 2004; 2005). Table 7 shows the results of OLS and ordered probit models, which are similar to those we obtained with structural equations.

5. DISCUSSION

Our goal was to study the determinants of reverse auction use by buyer firms. We proposed a theoretical model building on the transaction cost and inter-organizational reasoning. We find that product specialization and non-contractibility have particularly strong influences on reverse auction use.

The results support the argument that buyers will often use a small number of supplier relationships even as IT innovation changes the way in which firms manage the relationships. We find that non-contractibility arising from needs for quality, technology investments, information exchange, responsiveness, trust, and flexibility leads buyers to avoid electronic markets in which they would deal with a wide range of suppliers. These results are also consistent with Bensaou (1997)’s finding of relational characteristics as the most robust predictor of buyer-supplier cooperation than asset specificity or IT use. Our results complement Subramani’s (2004) study of multiple suppliers of one buyer firm, which identified the importance of supplier investments in business processes and domain knowledge.

Although electronic markets allow buyers to find the lowest cost input suppliers, our study points to the importance of non-price factors consistent with previous research. For example, one of the items in the Helper’s (1991) survey assessed the change in criteria that buyers used to choose suppliers over a five-year period from 1983-1988. The analysis showed that: “price went up the least, while quality increased the most to become the most important single criterion” (p. 20). Our study suggests the continued importance of non-price factors in buyer-supplier relationships.

Beyond explaining reverse auction use by employing transaction cost and incentive
considerations, this research surfaces apparent theoretical tensions within the governance related arguments of two prominent information systems theories. If, consistent with recent research (Chatterjee and Watson 2005; Wang and Archer 2004), one construes use of Internet-enabled reverse auctions as suggestive of intent to use a larger supplier pool, one can interpret our results as providing a formal empirical test of a corollary of the electronic markets hypothesis, which suggested that information technology would lead to greater use of arms length relationships with many suppliers. Reverse auctions enable such arms length relationships by allowing firms to efficiently locate suppliers and award contracts to them primarily based on price. The EMH prediction was based on the role of asset specificity in exchange relationships. This study extends the EMH and points to the need to consider non-contractible factors. Our results suggest the importance of recognizing non-contractible factors and lend support to Hess and Kemerer’s (1994) observation that: “the underlying hypothesis (i.e., electronic market hypothesis) will require augmentation in order to fully explain the results” (p. 251).

Extending the reasoning suggests that the degree of non-contractibility in the exchange relationship between the buyer and supplier will have an important influence on buyers’ use of reverse auctions. Traditional asset specificity may be a less important issue in such cases. Indeed, asset specificity is not a problem if firms can write complete contracts to govern the exchange processes, even if the relationships involve highly dedicated assets. Arms length agreements such as reverse auctions would be most uncommon when the issues associated with non-contractibility are more salient in the exchange relationship. In TCE, asset specificity is an issue from a supplier perspective because of the risks involved in fully protecting the value of such investments through contract. From a buyer perspective, asset specificity is an issue because it can raise costs due to supplier risk justifying use of a hierarchy like arrangement. However, asset specificity is not an issue for a buyer if the buyer can find a supplier willing to supply a specific part for a reasonable price. This example clarifies that it is not so much the asset specificity but the difficulty of anticipating and handling of the adaptation clauses in the contract that determines the governance choice.

The relative importance of non-contractibility and asset specificity becomes critical when buyers
need unspecifiable exchange support from suppliers. Typically, non-contractibility becomes salient when the degree of uncertainty concerning the nature of the support that the firms will need to provide each other rises to such an extent that parameters such as performance guarantees and non-compliance penalties become vague and impossible to enforce. Such issues are common in many modern supply relationships, particularly those involving products that face ongoing changes in underlying technology or in the nature of market demand. Growth of the service sector in the modern economy further underscores the importance of non-contractibility because information technology and flexible manufacturing technologies are progressively causing a decline in asset specificity (Milgrom and Roberts 1990).

Thus, there is a need to focus on the effects of the intangible and largely non-contractible aspects of underlying relationships that may not co-vary with transaction specific investments. If buyers and suppliers can contract on the contingencies that might arise in a relationship, then even a dedicated asset can be made fully contractible and will not pose an opportunism-related hazard to the contracting parties. However, if the parties cannot write a fully contingent contract for even a general asset, then one or both parties will be exposed to the requirements of non-contractible performance parameters.

To illustrate further, consider an auto component manufacturer (A) that buys slit and cut-to-length steel sheets from a steel service center (B). Although B may not have invested in slitting or cut-to-length production lines specifically for A’s requirements, so that its investments involve general assets, during the course of working together B may gain a better understanding of A’s requirements than what A could specify in a contract. Arguably, one might consider a better understanding arising out of two parties working together as a form of asset specificity, although viewing this as a form of asset specificity runs the risk of stretching the original definition of asset specificity, perhaps even approaching the point of making the theory irrefutable (Popper 1959). Moreover, this form of asset specificity does not apply in situations when B utilizes the knowledge gained from its interactions with customers other than A to provide greater benefits to A. For example, Boulding, Staelin, Ehret and Johnston (2005) note that Amazon.com creates value for a customer through information drawn from other customers, an example that requires no specific investments by Amazon for a given customer. Thus, in situations like these, B’s
understanding of A’s operations is a non-contractible parameter that does not involve asset specificity. This example illustrates a case in which non-contractibility arises in a relationship without a supplier having to make specific investments to support particular transactions for a buyer.

This research points to non-contractibility as a complement of traditional asset specificity. By augmenting the traditional asset specificity argument with a consideration of non-contractible factors, we gain a more nuanced understanding of the complexities of buyer-supplier relationships (Dai and Kauffman 2001). In a recent meta-review of thirty years of empirical studies, David and Han (2003) found that out of 107 independent statistical tests for asset specificity, only 60% supported the predictions and 4% significantly contradicted TCE. Given that asset specificity is the locomotive of TCE, there is a need to extend TCE either by enriching the notion of asset specificity to consider non-contractible attributes of exchange relationships or by considering non-contractibility as a separate and increasingly important dimension of exchange relationships that affects governance choice.

The results also have managerial implications. It is important for buyers to carefully choose products for procurement through electronic market mechanisms such as reverse auctions. An indiscriminate use of electronic markets by buyers may alienate loyal suppliers and such suppliers may react by under-investing in the non-contractible parameters of a relationship because they face pressure to be competitive in reverse auctions. The results showing that satisfied buyers are likely to continue business with their suppliers even if they are not the lowest bidders in the auction process should be reassuring to suppliers. These findings suggest that there are payoffs from investment in non-contractible parameters and relational capital.

The study has two primary limitations. First, the research is based on self-reported reverse auction use behavior and the factors influencing such decisions for different categories of products. There is a need to extend our findings by collecting detailed product and supplier characteristic archival data. Second, we covered a large cross-section of firms in the U.S. automotive industry in order to achieve generalizability. A useful extension of this research may be to conduct an in-depth study of a select group of companies that examines the buyer motivation for selective use of reverse auctions for specific
products. Such studies will enhance our understanding of the situational and contextual factors that are difficult to control in large-scale survey based research.

Several other areas offer promise for future research. First, it would be useful to identify parameters that affect cost savings from reverse auctions, particularly when firms adopt reverse auctions for products that score low on non-contractible parameters. Reverse auction parameters affecting cost reductions could include the number of participating suppliers, participation of the incumbent supplier in the auction, reserve price, and information that is available to auction participants (Bapna, Goes and Gupta 2001; Bapna et al. 2004). Second, it would be useful to investigate the drivers of cost reductions through reverse auctions, such as whether cost reductions arise from heightened competition or stem from IT-enabled reduced transaction and co-ordination costs. Third, future research should also investigate the determinants of adoption of other electronic market functionalities employing the approach used in this paper. Such studies will be useful in generalizing the theoretical framework used in this study.

To conclude, this paper studies the importance of product and relationship characteristics that influence buyers’ choice of governance mechanisms that affect the size of the supplier pool. Based on field data collected from firms in the automotive industry, we found that greater non-contractibility in an exchange relationship led to less use of reverse auctions. The study has implications for research in transaction cost economics because the notion of non-contractibility complements the traditional concept of asset specificity that is the driver of transaction cost economics. Non-contractibility becomes even more descriptive of the underlying transactions between buyers and suppliers as the importance of intangibles and services grows in the economy.
REFERENCES


Figure 1: Conceptual Model
### Table 1: Dimensions of Non-Contractibility

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Definition</th>
<th>References</th>
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<tbody>
<tr>
<td>Quality</td>
<td>Manufacturing capability, warranty implications, and criticality in terms of interaction with other components in an assembly.</td>
<td>Cusumano and Takeishi (1991), Takeishi (2001)</td>
</tr>
<tr>
<td>Technological</td>
<td>Supplier’s track record of continuous improvement in existing products, development of new products and investment in keeping abreast with technological developments.</td>
<td>Helper (1991), Takeishi (2001)</td>
</tr>
<tr>
<td>Investments</td>
<td></td>
<td>Cusumano and Takeishi (1991), Helper (1991),</td>
</tr>
<tr>
<td>Information</td>
<td>Exchange of proprietary information between buyer and supplier for cost reduction and involvement in planning and goal setting activities.</td>
<td>Takeishi (2001), Dyer (1997), Monczka et al.</td>
</tr>
<tr>
<td>Exchange</td>
<td></td>
<td>(1998)</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>Supplier’s sensitivity and ability to respond quickly to buyer’s needs and to keep buyer updated on the requests.</td>
<td>Johnston and Lawrence (1988), Goodhue and</td>
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<td></td>
<td></td>
<td>Thompson (1995)</td>
</tr>
<tr>
<td>Trust</td>
<td>Buyer’s perception about supplier’s trustworthiness, confidence in supplier, and belief that supplier will honor its promises.</td>
<td>Dyer (1997), Zaheer and Venkatraman (1994),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Johnston and Lawrence (1988)</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Willingness of supplier to modify a contract, make necessary adjustments, and react to buyer’s requests that may be beyond the terms of a contract.</td>
<td>Young-Ybarra and Wiersema (1999)</td>
</tr>
</tbody>
</table>

### Table 2: Profile of the Firms in the Sample (N=152)

<table>
<thead>
<tr>
<th>Firm Type</th>
<th>Percentage of Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEMs</td>
<td>20%</td>
</tr>
<tr>
<td>Tier 1 component manufacturer</td>
<td>84%</td>
</tr>
<tr>
<td>Tier 2 component manufacturer</td>
<td>66%</td>
</tr>
<tr>
<td>Tier 3 component manufacturer</td>
<td>30%</td>
</tr>
<tr>
<td>Tier 4 component manufacturer</td>
<td>8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Firm Size – Revenues in Million $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $100 Million</td>
</tr>
<tr>
<td>More than 100 million but less than $1 Billion</td>
</tr>
<tr>
<td>More than $1 Billion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Firm Size – Number of Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 500</td>
</tr>
<tr>
<td>More than 500 but less than 5000</td>
</tr>
<tr>
<td>More than 5000 but less than 10000</td>
</tr>
<tr>
<td>More than 10000 but less than 50000</td>
</tr>
<tr>
<td>More than 50000</td>
</tr>
</tbody>
</table>

*Figures do not sum up to 100% because of multiple responses for firm type.*
Table 3. Measurement Model: Parameter Estimates and Reliability

<table>
<thead>
<tr>
<th>Construct and Indicators</th>
<th>Standardized Loading</th>
<th>Composite Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-contractibility (NC): Second order construct consisting of two first-order sub-constructs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First order sub-construct:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task Based Non-contractibility (NCA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality (NC1)</td>
<td>0.59(^1)</td>
<td></td>
</tr>
<tr>
<td>Technological Investments (NC2)</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Information Exchanges (NC3)</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>First order sub-construct:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction Based Non-contractibility (NCB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responsiveness (NC4)</td>
<td>0.81(^1)</td>
<td></td>
</tr>
<tr>
<td>Trust (NC5)</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>Flexibility (NC6)</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>Asset Specificity (AS): First order construct</td>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td>Product Customization</td>
<td>0.42(^1, 2)</td>
<td></td>
</tr>
<tr>
<td>Equipment Specificity</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Labor Specificity</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>Business Process Specificity</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>JIT Needs</td>
<td>0.42 (^2)</td>
<td></td>
</tr>
<tr>
<td>Reverse Auction Use (RAU): Second order construct consisting of three first-order sub-constructs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First order sub-construct:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse auction use corresponding to task based non-contractibility (RAU1)</td>
<td></td>
<td>0.98</td>
</tr>
<tr>
<td>LNC1</td>
<td>0.96(^1)</td>
<td></td>
</tr>
<tr>
<td>LNC2</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>LNC3</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>First order sub-construct:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse auction use corresponding to interaction based non-contractibility (RAU2)</td>
<td></td>
<td>0.92</td>
</tr>
<tr>
<td>LNC4</td>
<td>0.76(^1)</td>
<td></td>
</tr>
<tr>
<td>LNC5</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>LNC6</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>First order sub-construct with single composite indicator: Reverse auction use corresponding to asset specificity (RAU3)</td>
<td></td>
<td>0.95</td>
</tr>
</tbody>
</table>

\(^1\) Constrained Parameter for identifying the measurement model
\(^2\) Items AS1 and AS5 have relatively small standardized factor loadings, but measurement and structural models that omitted AS1 and AS5 reported similar results (Appendix 1 provides item descriptions).
\(^3\) All factor loadings are significant at p<0.01.

Table 4. Correlations and Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Reverse Auction Use (RAU)</td>
<td>3.2</td>
<td>0.9</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Non-contractibility (NC)</td>
<td>5.6</td>
<td>0.7</td>
<td>2</td>
<td>7</td>
<td>-0.16</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Asset Specificity (AS)</td>
<td>5.3</td>
<td>1.0</td>
<td>1</td>
<td>7</td>
<td>-0.10</td>
<td>0.74</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Product Specialization</td>
<td>0.5</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
<td>-0.11</td>
<td>0.01</td>
<td>0.13</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Information System Compatibility</td>
<td>4.4</td>
<td>1.0</td>
<td>2</td>
<td>7</td>
<td>0.14</td>
<td>0.11</td>
<td>0.14</td>
<td>0.00</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Competitive Strategy (Differentiation)</td>
<td>3.9</td>
<td>0.7</td>
<td>1</td>
<td>7</td>
<td>0.01</td>
<td>-0.05</td>
<td>-0.04</td>
<td>0.00</td>
<td>0.04</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7 Supply Chain Strategy (Relationship orientation)</td>
<td>5.9</td>
<td>1.0</td>
<td>3</td>
<td>7</td>
<td>-0.18</td>
<td>0.08</td>
<td>0.13</td>
<td>0.00</td>
<td>-0.03</td>
<td>-0.04</td>
<td>1</td>
</tr>
<tr>
<td>8 Firm Size (Revenues)</td>
<td>3.5</td>
<td>0.8</td>
<td>2</td>
<td>5</td>
<td>0.25</td>
<td>0.00</td>
<td>0.08</td>
<td>0.00</td>
<td>0.33</td>
<td>-0.09</td>
<td>-0.08</td>
</tr>
</tbody>
</table>
Table 5. Parameter Estimates of the Structural Equation Models Explaining Reverse Auction Use  
(t values in parentheses; positive coefficient = more likely to use reverse auctions; n=304)

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Specificity (H1)</td>
<td>β₁₁</td>
<td>-0.21*</td>
<td>β₂₁</td>
</tr>
<tr>
<td>Product Specialization (H2)</td>
<td>β₁₂</td>
<td>-0.28**</td>
<td>β₂₂</td>
</tr>
<tr>
<td>Non-contractibility (H3)</td>
<td>β₁₃</td>
<td>-0.50**</td>
<td>β₂₃</td>
</tr>
<tr>
<td>Supply Chain Strategy (Relationship Orientation)</td>
<td>β₁₄</td>
<td>-0.19***</td>
<td>β₂₄</td>
</tr>
<tr>
<td>Firm Size (Revenues)</td>
<td>β₁₅</td>
<td>0.39***</td>
<td>β₂₅</td>
</tr>
<tr>
<td>Information System Compatibility</td>
<td>β₁₆</td>
<td>0.14**</td>
<td>β₂₆</td>
</tr>
<tr>
<td>Competitive Strategy (Differentiation)</td>
<td>β₁₇</td>
<td>0.04</td>
<td>β₂₇</td>
</tr>
</tbody>
</table>

**Fit Indices**

- Chi-Square: 318.34***, 301.43***, 721.87***
- Chi-Square / df: 3.09, 2.58, 3.47
- GFI: 0.90, 0.90, 0.84
- NFI: 0.94, 0.94, 0.90
- NNFI: 0.94, 0.95, 0.91
- CFI: 0.96, 0.96, 0.93
- RMSEA: 0.08, 0.07, 0.09
- AIC: 418.34, 409.43, 857.87

*** p<0.01; ** p<0.05; * p<0.10

---

Table 6. Student’s t-tests for the Effect of Buyer Satisfaction on Reverse Auction Use

<table>
<thead>
<tr>
<th>Panel A (Survey responses)</th>
<th>Mean (s.d.) (1=Strongly disagree, 7=Strongly agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. We would consider using reverse auctions only if we are dissatisfied with our incumbent suppliers.</td>
<td>3.24 (1.82)</td>
</tr>
<tr>
<td>b. We would consider using reverse auctions even if we are completely satisfied with our incumbent suppliers.</td>
<td>3.96 (2.16)</td>
</tr>
<tr>
<td>c. We are likely to reward our loyal suppliers by continuing business with them even if they are not the lowest bidders in the reverse auction.</td>
<td>4.68 (1.70)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B (p-values)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• two sample t-test with unequal variance: items a &amp; b</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>• two sample t-test with unequal variances: items b &amp; c</td>
<td>p &lt; 0.05</td>
</tr>
</tbody>
</table>

---

Table 7. Additional Models Explaining Reverse Auction Use  
(positive coefficient = greater likelihood of reverse auction use; n=304)

<table>
<thead>
<tr>
<th>A. OLS with Heteroskedasticity Consistent Standard Errors¹</th>
<th>B. Ordered Probit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>Asset Specificity (H1)</td>
<td>0.049</td>
</tr>
<tr>
<td>Product Specialization (H2)</td>
<td>-0.203***</td>
</tr>
<tr>
<td>Non-contractibility (H3)</td>
<td>-0.262**</td>
</tr>
<tr>
<td>Information System Compatibility</td>
<td>0.068</td>
</tr>
<tr>
<td>Competitive Strategy (Differentiation)</td>
<td>0.021</td>
</tr>
<tr>
<td>Supply Chain Strategy (Relationship orientation)</td>
<td>-0.144**</td>
</tr>
<tr>
<td>Firm Size (Revenues)</td>
<td>0.229***</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.131</td>
</tr>
</tbody>
</table>

*** p<0.01; ** p<0.05; * p<0.10 (one tailed) ¹The OLS models included an intercept term.
Appendix 1: Constructs and Questionnaire Items

We are interested in knowing how important the following product and supplier characteristics are to the purchase of production inputs. Please indicate the importance (1=Low, 7=High) of each product or supplier characteristic. Then, indicate the likelihood (1=Low, 7=High) of your adopting reverse auctions for sourcing from a supplier with such characteristics.

Non-Contractibility (NC): This item included sub-constructs for Quality, Innovativeness, Information Exchanges, Responsiveness, Trust, and Flexibility. The sub-constructs used several items (1=strongly disagree, 7=strongly agree)

Quality (NC1)
- a. Product has a high manufacturing quality requirement.
- b. Product performance critically affects performance of other parts or components.
- c. Product has a significant risk of warranty liabilities.

Technological Investments (NC2)
- a. Product requires continuous technological innovation.
- b. Supplier that keeps abreast with latest technological developments.
- c. Supplier that develops new technology products critical to your success.

Information Exchanges (NC3)
- a. Product requires significant sharing of your proprietary information with the supplier.
- b. Supplier that shares their proprietary information with you.
- c. Supplier that allows your participation in their planning and goal-setting activities.
- d. Supplier that shares detailed information on their cost structure.

Responsiveness (NC4)
- a. Supplier that proactively anticipates your emerging needs.
- b. Supplier that is responsive to your requests.
- c. Supplier that keeps you updated on your requests.

Trust (NC5)
- a. Supplier that is absolutely trustworthy.
- b. Supplier that honors their promises.
- c. Supplier that establishes a very high level of mutual confidence with your firm.

Flexibility (NC6)
- a. Supplier that will be flexible in response to requests that may be beyond the terms of your contract.
- b. Supplier will modify the agreement rather than stick to original terms if an unexpected situation arises.
- c. Supplier will make continuous adjustments to cope with changing circumstances.

Asset Specificity (AS)
- a. Product needs significant customization to meet your requirements. (AS1)
- b. Supplier will invest in manufacturing equipment specifically for your requirements. (AS2)
- c. Supplier has technical labor skills that are unique to your requirement. (AS3)
- d. Supplier understands your business processes in order to satisfy all your needs. (AS4)
- e. Supplier will be able to satisfy your JIT (Just in time) inventory requirements. (AS5)

Likelihood of Reverse Auction Use (RAU): Respondents rated the likelihood of reverse auction use (1=low, 7=high) for production goods with varying asset specificity and non-contractibility. For structural equation modeling, we used second order constructs with partially aggregated sub-constructs as shown in Table 3.

Please indicate the extent to which you agree or disagree with each following statement. (1=Strongly disagree, 7=Strongly agree)

Information System Compatibility
- a. We are comfortable with web-based information technologies.
- b. We have invested a substantial amount of time and money in EDI (Electronic Data Interchange) technologies.
- c. We already use the Internet for procurement purposes.
- d. We share procurement related information electronically between units within our firm.
- e. Our firm has automated the ordering process for production goods (raw materials).
- f. We can easily exchange and integrate data electronically from our major suppliers.
- g. Our major suppliers have computer systems in place to quickly respond to our product enquiries.
- h. Our major suppliers can electronically process business documents (e.g. invoices, designs, POs).

Differentiation Competitive Strategy
- a. We continuous attempt to distinguish our products and services from those of our competitors on features other than price.
- b. We aggressively attempt to reduce our costs of providing products and services to our customers (reverse scored)

Relationship-Oriented Supply Chain Strategy
- a. We strive to develop long-term relations with our major suppliers.
- b. We change our suppliers frequently to get the best prices. (reverse scored)

Sales Revenue last year: Scale of 1 to 5 (< $1 million, $1-$10 million, $10-$100 million, $100 million-$1 billion, > $1 billion).