Information Technology and the Number of Suppliers in a Supply Chain: Is there a Relationship?

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Abstract

This work addresses how the number of suppliers employed by a manufacturer relates to its use of electronic procurement (e-procurement). Using data from the U.S. manufacturing industry, we find a surprising result that there is non-correlation between e-procurement and number of suppliers at the aggregate level. However, when we distinguish the type of goods purchased, we find that e-procurement is associated with using more suppliers for custom goods while fewer suppliers for standard goods. The finding for custom goods may sound contradictive to the prior literature proposing a "move to the middle," but is consistent with a TCE-based notion that custom goods procurement involves more asset-specific relationships than standard goods. Further, the positive association between e-procurement and number of suppliers of custom goods is negatively moderated by the degree of buyer-supplier systems integration, which is consistent with the argument that deeper integration of buyer and supplier information systems can help buyers obtain better "fit" for their customized requirements. This is an alternative to achieving better fit by employing more suppliers as proposed in the extant literature.

Keywords: supply chain relationships, number of suppliers, electronic procurement, transaction costs economics, custom goods, systems integration

1. Introduction

The use of information technology (IT) is associated with new ways of coordinating supply chain relationships (Lee 2004). Researchers seek to link IT to governance of buyer-supplier transactions, most commonly using transaction cost theory (Williamson, 1975). One issue that has received attention in the information systems (IS) literature is the optimal number of suppliers that a firm should use, and how that is affected by the introduction of IT. Researchers have made conceptual arguments that IT could lead firms to work with either more (Malone et al., 1987) or fewer (Clemons et al., 1993) suppliers. Other work has highlighted the role of IT in the creation of value-added partnerships, in which firms leverage IT to integrate closely with a limited number of partners in supply chain relationships (Bakos and Brynjolfsson, 1993). Yet Internet-based technologies are said to enable firms to connect their information systems with more suppliers at a relatively low marginal cost (Seely Brown et al., 2002).

Empirically, the evidence is also mixed. There has been evidence of a shift towards the use of fewer suppliers in the electronics industry (Wall Street Journal, 2003). For instance, in the mid-1990s, Dell Computer reduced its supplier base by 75% while implementing major IT systems to better control production and supply chain operations. Yet a recent survey found IT use associated more frequently with an increased rather than a decreased supplier base (European Commission, 2006).

Therefore, the relationship of IT use to the number of suppliers with which firms do business is an important topic worthy of further research, both theoretically and empirically. In this work we specifically focus on *electronic procurement* (e-procurement), which refers to procurement processes that are conducted based on common data standards and via interorganizational linkages such as electronic data interchange (EDI) or the Internet (Mukhopadhyay and Kekre, 2002). This is the type of IT that is used directly to support transactions between buyers and suppliers and thus most likely to affect the choice of number of suppliers. We conducted a survey of U.S. manufacturing firms and used the data to investigate how e-procurement relates to number of suppliers. Our results contribute to the literature by showing differential relationships of IT use to number of suppliers for standard goods vs. for custom goods, and a moderating role of integration between buyers' and suppliers' information systems..

2. Transaction Cost Perspectives on Number of Suppliers

How firms decide on an optimal number of suppliers is of both theoretical and practical interest (Clemons et al., 1993; Bakos and Brynjolfsson, 1993; Gurbaxani and Whang, 1991). Transaction cost theory states that firms face the risk of opportunism when they are in a small numbers bargaining situation, particularly when relationship-specific investments are required (Williamson, 1975). It is generally expected that having more suppliers reduces the risk of opportunism, as the buyer is less dependent on any supplier. In addition, having more suppliers can reduce the cost of having to settle for a poor *fit* (i.e., for a less than ideal combination of product features, quality, and reliability of supply) (Bakos and Brynjolfsson, 1993). Nonetheless, using more suppliers raises coordination costs as the buyer must search, negotiate contracts, monitor and enforce compliance and coordinate efforts with each supplier. Thus, the number of suppliers chosen by any firm involves finding an optimal balance among the following key transaction factors—fit, coordination costs and risk of opportunism (Clemons et al., 1993).

IT can reduce coordination costs as procurement processes are standardized and automated, thus reducing the cost of working with more suppliers (Mukhopadhyay et al., 1995). Also, IT can reduce the costs of searching for new suppliers to achieve better fit (Garicano and Kaplan, 2001). On the other hand, IT might favor reducing the number of suppliers. The most important factor in this case is the potential of IT to reduce the risk of shirking or opportunism associated with a small numbers bargaining situation (Clemons et al., 1993).

Given these competing perspectives, whether or not IT use is associated with an increase or decrease in the number of suppliers depends on the balance of its impact on these factors—coordination cost, fit, and risk. The net impact depends in part on the marginal cost of buyer-supplier IT linkages, and the relationship specificity of the associated IT investments. If additional suppliers can be added easily to existing inter-firm IT systems such as those based on cheap technologies and open standards, then marginal coordination costs will be low and buyers are likely to work with more suppliers to achieve better fit. But if the marginal cost of making IT connections is high, as in the case of expensive technologies or relationship-specific interfaces (Subramani, 2004), the economics will favor working with fewer suppliers in order to reduce upfront costs and to recoup those investments over a larger volume of transactions with each partner (Clemons et al., 1993).

An additional factor that may influence number of suppliers used by a buyer firm is supplier incentive to make non-contractible investments (in quality, reliability or other performance measures), which can be created by reducing the supplier base (Bakos and Brynjolfsson 1993). Here a buyer firm may decide to accept a greater risk of opportunism to encourage its suppliers to make such investments in return for a greater share of the buyer's total business. Also, deeper integration of IT systems between firms may by itself require non-contractible investments on the part of the seller; hence sellers may need to be given incentives to make such investments.

3. Theory Extension and Hypothesis Development

We extend the perspectives above, by addressing the nature of the product being supplied and the type of IT employed in the buyer-supplier relationships. Each of the two factors can affect the relative importance of coordination cost, the cost of poor fit, risk of opportunism, and the importance of non-contractible investments. Each also can affect the impact of IT on those variables.

3. 1 Standard versus Custom Goods

Manufactured goods can incorporate both standard and custom parts and components. For a standard commodity input (such as most nuts, bolts, resistors, or memory chips), the potential cost of poor fit will be lower, as inputs from different suppliers are interchangeable. For custom components (such as car seats, application specific integrated circuits, or molded plastic enclosures), the importance of fit is high, as a highly specific part is required and only a few suppliers may be able to provide this input. Also, the cost of coordinating with suppliers is likely to be higher for custom goods, as suppliers need more information to meet unique requirements for the buyer. Finally, the risk of opportunism is likely to be lower for standard goods, as a buyer can easily find a substitute supplier if a current supplier tries to act opportunistically. For custom goods, the risk of relying on a small number of suppliers is greater, as asset-specific investments are likely to be involved and uncertainty is greater (Williamson 1975). Because of these differences, the potential impact of IT on costs associated with poor fit, coordination, or opportunistic behavior will thus be affected by the nature of the goods.

When a buyer uses IT to purchase standard goods, the buyer would be more concerned about reducing coordination costs than costs of poor fit and risk of opportunism. Standard goods have similar or identical characteristics from different sources of supply. Therefore, the benefits of improving fit, through transacting with a greater number of suppliers, might be limited. A buyer of standard goods can easily communicate product specifications using standard data formats, reducing marginal coordination costs with each supplier. This also makes it easier to switch to alternative suppliers and thereby decreases the risk of opportunism by existing suppliers. These effects are consistent with the argument made by Clemons et al. (1993) that IT can lower coordination cost without increasing the inherent transaction risk associated with a small number of suppliers. Furthermore, while IT helps a buyer search among multiple suppliers for the lowest prices for standard goods, once a search is done and suppliers are chosen, the buyer often can get even better pricing by concentrating orders with fewer suppliers to obtain volume discounts (Elmagraby, 2000). This further motivates the buyer to reduce the number of suppliers. Based on this discussion, we propose the following hypothesis:

H1: In the context of purchasing standard goods, the use of e-procurement is negatively associated with the number of suppliers.

In contrast, when purchasing custom goods, controlling the risk of supplier opportunism and the costs of poor fit is likely to be more important. Since custom goods have more specific features tailored to a buyer's needs than standard goods, achieving a high degree of fit is more important. One way of achieving better fit is to find and evaluate more suppliers, which can be done at lower cost using IT (Bakos and Brynjolfsson, 1993).

Also, since higher levels of coordination are needed with suppliers of custom inputs to ensure availability and share technical information, it will take more time and money for a buyer to set up relationships with alternative suppliers. Consequently, the buyer is more likely to be locked-in to existing suppliers for custom goods than standard goods, creating a greater risk of opportunism (Milgrom and Roberts, 1992). One mechanism for a buyer to reduce opportunism risk is to increase the supplier base and reduce the buyer's reliance on any supplier (Hart and Saunders, 1997; Williamson, 1975). The use of IT to lower search and coordination costs makes it economically feasible to increase the supply base when potential for opportunism is high (Malone et al., 1987). Therefore we hypothesize:

H2: In the context of purchasing custom goods, the use of e-procurement is positively associated with the number of suppliers.

3. 2 The Type of IT Employed

The above relationships may be moderated by the type of IT employed. The use of IT to automate routine purchasing process, such as purchase orders or invoices, can be accomplished by adoption of established protocols such as EDI or XML-based standards (Mukhopadhyay et al. 1995; Zhu et al., 2006). The marginal cost of adding another trading partner in this case is likely to be relatively low once the firm has put in the necessary infrastructure and adapted its own processes and systems to generate data in the required formats. Adoption of such standardized technologies enables buyers to use more suppliers in order to achieve better fit without a corresponding increase in coordination costs (Bakos and Brynjolfsson, 1993).

By contrast, deeper integration of processes between firms is likely to require more extensive IT integration, for instance sharing data between enterprise systems, or adoption of compatible applications such as computer-aided design (CAD) or supply chain management systems (Mukhopadyay and Kekre, 2002; Rai et al., 2006). In such cases, the marginal coordination cost associated with integrating additional suppliers may be high (Bakos and Brynjolfsson, 1993). Furthermore, after these linkages are established, ongoing coordination costs will be reduced and asset specificity increased. As a result, we expect differential relationships between IT use and the number of suppliers when such enhanced integration is created. Along this line, we posit *buyer-supplier systems integration* as the relevant dimension of the type of IT deployed, measured as to the degree to which a buyer firm's systems are integrated with systems and databases of suppliers (Mukhopadhyay and Kekre, 2002; Rai et al., 2006).

Systems integration provides the IT infrastructure for more "explicit coordination" between buyers and suppliers (Clemons et al., 1993; Rai et al., 2006). Also, systems integration enhances information sharing and streamlines communications between buyers and suppliers (Mukhopadhyay and Kekre, 2002; Rai et al., 2006). Such enhanced information sharing can enable suppliers to meet the more complex product requirements of custom goods. For instance, an electronic linkage that maps suppliers' engineering data with the buyer's procurement database helps suppliers responsively adapt products and processes to the buyer's needs. As such, systems integration lowers the need for the buyer to work with more suppliers of custom goods, and therefore can serve as an alternative means to achieve better "fit."

In addition, establishing such deep buyer-supplier systems integration is more expensive than using e-procurement simply to automate transactions. Automatic invoicing and payment systems are becoming commodity-like and access to these systems can be gained easily through the marketplace (Rai et al., 2006). In contrast, developing deeper systems integration requires investments that are specific to the coordination procedure (Subramani, 2004). Systems integration thus entails higher upfront investments, which in turn may lead to the use of fewer suppliers. Finally, buyer-supplier systems integration is a form of non-contractible investments. To motivate suppliers to make this type of non-contractible investments, the buyer may choose to work with fewer suppliers to give each a greater volume of business. These effects suggest that although we expect a positive relationship between e-procurement and the number of suppliers for custom goods (H2), the positive relationship would be negatively moderated by the degree of buyer-supplier systems integration.

H3: In the context of purchasing custom goods, the positive relationship between e-procurement and the number of suppliers is negatively moderated by buyer-supplier systems integration.

Finally, we note that we would expect a much weaker moderation effect of systems integration in the context of purchasing standard goods. The reason is that the major benefit of systems integration for the buyer is improved "fit" which, as discussed above, may not be a critical consideration for buyers of standard goods. Also, the need for relationship-specific investments is less when standard goods are involved. Therefore these factors are less likely to come into play as they do with custom goods. This leads to our final hypothesis:

H4: In the context of purchasing standard goods, buyer-supplier systems integration has a weaker moderation effect than for custom goods.

3. 3 Control Variables

In addition to e-procurement, firm- and industry-specific characteristics and the environment where e-procurement is used may also affect the number of suppliers. Based on a review of the literature, our study includes the following control variables. First, we control for two firm characteristics, scale and scope, that may influence the size of the supplier base. Then, we control for the industry characteristics, by examining the role of demand uncertainty and industry concentration. Finally, we consider the technology environment for e-procurement by investigating the role of a firm's internal IT. In our research setting, we also need to control for the extent to which suppliers use compatible IT systems for electronic transactions and information sharing, and the extent to which the use of IT to coordinate with suppliers may require the firm to acquire or develop additional technical and managerial skills.

4. The Empirical Study

4.1 Data and Variables

Our data were collected from two sources, a primary survey and the Compustat database. We conducted a firm-level survey in the manufacturing industry to obtain information about e-procurement, product types, and the number of suppliers. The survey was conducted during June-July 2005 using computer-aided telephone interviews. We used random sampling to minimize potential biases. Our final dataset includes 150 data points, with a response rate of 32.2%. We then augmented the dataset by including variables from the Compustat database, which were used for constructing measures for firm scale and scope and for industry characteristics. Table 1 shows sample characteristics and Table 2 lists the detailed definitions for all variables.

---Insert Tables 1 and 2 about here---

4.2 Results of Hypothesis Testing

We estimated regressions of ln(*#SUP*) against e-procurement (*EPCUS*, *EPSTD*, *EPTOT*), buyer-supplier systems integration (*BSSI*), and interaction terms between e-procurement and buyer-supplier systems integration, controlling for firm scale and scope, industry characteristics, and the variables concerning IT environment.

Table 3 reports the regression results. As shown in Column (1), the coefficient of *EPTOT* is non-significant, suggesting that e-procurement in general has no significant correlation with the number of suppliers. Column (2) of Table 3 analyzes e-procurement in two contexts, purchasing custom goods vs. purchasing standard goods. The coefficient of *EPCUS* is positive and significant, while the coefficient of *EPSTD* is negative and significant.

These results indicate that in the context of purchasing custom goods, e-procurement is *positively* related to the number of suppliers. In contrast, in the context of purchasing standard goods, e-procurement is *negatively* related to the number of suppliers. When the analysis aggregates data of standard and custom goods, there is non-correlation between r-procurement and number of suppliers. When the type of goods in procurement is taken into consideration, the empirical evidence supports our expectations on how e-procurement may affect the number of suppliers (H1 and H2). This underscores the importance of taking into account the type of products under e-procurement.

Column (3) of Table 3 includes moderation effects of buyer-supplier systems integration. There is a significant and negative interaction between *BSSI* and *EPCUS*, suggesting that buyer-supplier systems integration negatively moderates the relationship between the number of suppliers and e-procurement for purchasing custom goods. This can be expressed mathematically as:

$$\partial \ln(\#SUP) \big/ \partial EPCUS = 0.23 - 0.20 \times BSSI,$$

which indicates that, in the context of purchasing custom goods, e-procurement tends to increase the number of suppliers, but this increase is limited by stronger buyer-supplier systems integration. In contrast, the interaction term between *BSSI* and *EPSTD* is non-significant, indicating non-significant moderation of systems integration in the context of purchasing standard goods. These results support our hypotheses about the moderation effects of buyer-supplier systems integration (H3 and H4).

Column (4) of Table 3 presents our full model, including all controls. Compared to Columns (2) and (3), we have observed qualitatively consistent results. Column (5) estimates an interaction term between *BSSI* and *EPTOT*, which turns out to be non-significant. A plausible explanation is that, since buyer-supplier systems integration plays a significant moderating role only for custom goods (see Column (4)), there is no significant moderation effect on the overall e-procurement. It is possible that information is lost as measures are aggregated. Finally, Column (6) excludes the non-significant controls in Column (4) and re-estimates the regression. The significance levels of all coefficients in Column (6) are consistent with the results in Column (4) and no significant coefficients change in sign. Thus, our empirical results are robust.

Among the controls, ln(*SALES*) has a significant coefficient in all regressions. This is intuitive in that large firms in general have more suppliers. Demand uncertainty (*UNCER_DIF*) has a significant and negative coefficient, which is consistent with the theoretical expectation that coordination costs increase and the number of suppliers decreases with demand uncertainty. Within IT environment, *INTERNALIT* has a significant and positive coefficient. Internal IT can reduce both the internal production costs and the external coordination costs. Our results show that, on balance, internal IT leads to using more suppliers.

-----Insert Table 3 about here----

4.3 Regression Diagnostics

Following the procedure described by Cohen (1988) and using 0.05 as the cutoff for type I error, we found that the statistical power in each of the regressions in Table 3 is above 0.8. According to the Jarque-Bera test, our sample does not violate the normality assumption. Checking the Belsley-Kuh-Welsch (BKW) index suggested no harmful multicollinearity. We also used a heteroskedasiticity-robust variance estimator in all of the regressions.

There is a potential issue of endogeneity with respect to e-procurement in our regression equations. For example, if a firm needs to purchase more custom goods in its entire procurement, it may need to contact a greater number of suppliers, which may motivate it to deploy e-procurement. Also, e-procurement for custom goods and e-procurement for standard goods could be correlated since they are both supported by a firm's IT capability. We used a two-stage least squares (2SLS) method to address the potential endogeneity. At the first step, *EPCUS* was regressed on those variables used for the regression explaining number of suppliers and five other potential factors (a firm's IT capability compared to major competitors and its ability to derive benefits from IT, number of years using e-procurement, percentage of build-to-order in production, and percentage of custom goods in the entire procurement). At the second step, we re-estimated the regression for number of suppliers, using the predicted value for *EPCUS* obtained at the first step. We obtained qualitatively unchanged results. Thus, endogeneity does not seem to affect the primary inferences drawn from Table 3.

5. Discussion

5.1 Major Findings

Our objective in this research is to empirically test, in the context of e-procurement, the relationship of IT use to the number of suppliers engaged by buyer firms, and to incorporate two new factors: the nature of the product and the type of IT used. In doing so, we have both tested and extended existing theory.

Our initial models (see Columns (1) and (5) of Table 3) analyze the association of e-procurement with the number of suppliers for all of a buyer's purchases. In this case we do not find support for the argument that IT use will lead buyers to work with fewer suppliers as prior theoretical work predicted (Clemons et al., 1993; Bakos and Brynjolfsson, 1993). Conversely we also do not find support for the hypothesis that IT leads to the use of more suppliers as would be expected if IT leads to reliance on outside suppliers for more of a firm's production inputs (Malone et al., 1987). The lack of significant results may indicate that IT simply does not relate to number of suppliers, or that the relation of IT to number of suppliers might only be significant for certain types of purchases but the analysis at this aggregate level is not able to detect.

The latter interpretation is supported when we look at custom goods and standard goods separately (Column (2) of Table 3). For custom goods, greater use of e-procurement is associated with buying from more suppliers. This is consistent with the argument that the ability to use IT to achieve better fit without a corresponding increase in coordination costs is of greater importance for custom goods. It also is consistent with the argument that the risk of supplier opportunism is greater for custom goods (Bensaou and Venkatraman, 1995), and firms may use IT to reduce that risk by increasing their supplier base (Hart and Saunders, 1997).

For standard goods, we find that greater use of e-procurement is associated with using fewer suppliers. This can be explained by the fact that fit is not as important for standard goods, and the risk of opportunism is not as serious as buyers can easily find alternative suppliers; hence the benefits of using more suppliers are limited. Rather than use IT to do business with more suppliers, buyers may search for low cost suppliers of standard goods and then concentrate their purchases with a few suppliers to obtain volume discounts (Elmagraby, 2000). The fact that we obtain opposite results for custom and standard goods may explain why the results are insignificant when the two are combined into one measure (Columns (1) and (5) of Table 3).

We also find that the impact of IT depends on the type of information systems in use in the case of custom goods (Columns (3) and (4) of Table 3). While e-procurement is associated with use of more suppliers, systems integration between buyers and suppliers moderates that effect, leading to buying from fewer suppliers. This can be seen as evidence that buyers may use IT integration to achieve better fit (and stronger collaboration) with a smaller number of suppliers by sharing richer information about product and process requirements. This result confirms the observation that the manufacturing industry is moving toward value-added networks with supply chain partners, especially in the case of custom inputs, where firms look to develop strong partnerships with suppliers. Such explicit coordination may lower transaction risks of using a small number of suppliers by enabling better monitoring, while also increasing the marginal cost of coordination with additional suppliers, as more extensive IT integration is required. Buyer-supplier systems integration also likely requires relationship-specific investments to develop and maintain system compatibility as each partners' systems are upgraded and evolve. Such investments may only be made if suppliers are given a large enough share of the buyer's business to provide an adequate financial incentive.

5.2 Limitations and Future Research

First, we conducted analysis from a buyer's perspective, and did not address how suppliers would perceive the risk of buyer opportunism over the e-procurement platform and how their perception may influence buyer-supplier relationships. Future research can analyze the role of e-procurement in buyer-supplier relationships from a supplier's view. Second, our sample framework only covered manufacturing firms, which limited the generalizability of our results. Future research may cross-validate our model in the distribution sector which also uses IT in buyer-supplier relationships. Third, due to the cross-sectional nature of the dataset, we can only show associations between e-procurement and number of suppliers. Our methodology does not allow us to explore the causal impacts of IT. Hence, an important extension in future research is to conduct a longitudinal study, which can reflect the temporal changes in IT use and the number of suppliers and also investigate the causal relationships between them.

5.3 Concluding Remarks

To conclude, this study makes both empirical and theoretical contributions in understanding the relationship of IT use to organization of economic activities along the supply chain, specifically the number of suppliers that buyers select. Prior research has made conceptual arguments bolstered mainly by case studies and other qualitative information that IT would lead to the use of either more or fewer suppliers (Malone et al., 1987; Clemons et al., 1993; Bakos and Brynjolfsson, 1993). By testing these arguments quantitatively, we find no support for either relationship when looking at IT use and product procurement in the aggregate. This surprising result would seem to suggest that IT does not relate to number of suppliers. However, by going further to distinguish between the types of goods being purchased and the nature of IT use, we make theoretical contributions which are supported by our empirical results. These results are consistent with some predictions of transaction cost theory, but shed new light as highlighted below.

First, the fact that we get opposite results for standard and custom goods is consistent with the perspective that custom goods procurement involves more asset specific supplier relationships than standard goods, hence increasing the risk of opportunism in a small number bargaining situation. This distinction has not previously been made explicit, or tested empirically, in research on IT's relation to number of suppliers. Our results operationalize and test the distinction of custom and standard goods empirically and thus provide an important insight into the role of this dimension of asset specificity in organizing supply chain activities.

The difference in results for e-procurement and buyer-supplier IT integration shows that IT cannot be looked at as an undifferentiated input with uniform impacts, but that it is necessary to distinguish different types of interorganizational systems in modeling the impacts of IT. Specifically, our analysis here shows that further differentiation is needed to distinguish between transaction-oriented e-procurement systems and deeper integration of buyer and supplier information systems. In particular, deeper integration of buyer and supplier information systems can help buyers obtain better "fit" for their customized requirements. This challenges the approach to increasing fit through employing more suppliers as proposed in the extant literature. At a higher level, these issues are important as companies continue to seek most efficient ways to re-organize their supply chains, using IT to support different types of supplier relationships that match the type of goods procured.

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Table 1. Sample Characteristics (N=150)

Characteristics	Category	Frequency	Percent
Industry:	Industrial machinery and computer equipment (SIC=35)	35	23.3
	Electronic equipment (SIC=36)	32	21.3
	Instruments, medical and optical goods (SIC=38)	22	14.7
	Transportation equipment (SIC=37)	17	11.3
	Others (SIC=22, 23, 25-28, 30, 31, 34, 39)	44	29.4
Annual sales:	(mean=1435, median=102, S.D.=5415)		
(in million $US)	<10	14	9.3
	10-49	27	18.0
	50-199	34	22.7
	200-999	26	17.3
	>1000	26	17.3
	Missing	23	15.3
Number of employees:	(mean=6192, median=533, S.D.=18039)		
	<100	22	14.7
	100-499	34	22.7
	500-2999	35	23.3
	>3000	34	22.7
	Missing	25	16.7
Number of suppliers:	(mean=612, median=125, S.D.=1384)		
	<49	36	23.9
	50-149	34	22.7
	150-299	28	18.7
	300-999	20	13.3
	>1000	23	15.3
	Missing	9	6.0

Table 2. Variables

Variable	Definition	Data Source
ln(#*SUP*)	Number of suppliers (log-transformed)	Survey
EPCUS	The percentage of custom parts and materials for production that were purchased via e-procurement	Survey
EPSTD	The percentage of standard parts and materials for production that were purchased via e-procurement	Survey
EPTOT	The percentage of e-procurement in the entire purchase	Survey
BSSI	The degree to which the buyer firm's information systems are integrated with those of suppliers (5-point scale)	Survey
ln(*SALES*)	Annual sales (log-transformed), a proxy for firm scale	Compustat
ENTROPY	This is the entropy measure for firm scope: Suppose a firm has N industry segments, indexed by i. Let α_i=(the firm's sales in industry i)/(the firm's total sales). Scope is: $ENTROPY = \sum_{i=1}^{N} \alpha_i \ln(1/\alpha_i).$	Compustat
UNCER_DIF	We computed the total sales in an industry (3-digit SIC sector) during the past 15 years (1990-2004, in 1990 constant dollars), denoted as S_t (t=1990, 1991…2004). The standard deviation of the first difference of the time series $\ln(S_t)$ was used to proxy for demand uncertainty.	Compustat
HHI	Herfindahl-Hirschman Index (*HHI*) for industry concentration, the sum of the squares of the market shares of all firm in the 3-digit SIC industry	Compustat
INTERNALIT	Internal IT was taped by 4 items: Whether the firm had MRP, ERP, Shop Floor Management, and Production Planning and Forecasting in use. Factor scores (*INTERNALIT)*, obtained based on the four items through principle component analysis, were used to represent internal IT.	Survey
SUPTECH	Factor scores (*SUPTECH*) based on the following two items were used as a proxy for supplier use of compatible technologies: The degree to which existing suppliers process orders through the Internet, and the degree to which existing suppliers process orders using EDI (5-point scale).	Survey
SKILLREQ	Factor scores (*SKILLREQ*) based on the following two items were used to tap the difficulty of acquiring needed skills: Difficulty of finding staff with skills of managing Internet-based procurement, and difficulty of finding staff with skills of managing EDI (5-point scale).	Survey

Table 3. Regression Results

	(1)		(2)		(3)		(4)		(5)		(6)	
Dependent Var.=ln(*#SUP*)	β	(*t*-stat)	β	(*t*-stat)	β	(*t*-stat)	β	(*t*-stat)	β	(*t*-stat)	β	(*t*-stat)
E-procurement												
EPCUS			0.23	(1.91) *	0.23	(1.92) *	0.29	(2.74) ***			0.24	(2.20) **
EPSTD			-0.21	(-2.14) **	-0.17	(-1.66) *	-0.23	(-2.52) **			-0.20	(-2.39) **
EPTOT	0.02	(0.23)							0.05	(0.36)		
Moderation by integration												
BSSI					-0.13	(-1.36)	-0.08	(-0.62)	-0.08	(-0.62)	-0.11	(-1.37)
BSSI×EPCUS					-0.20	(-1.81) *	-0.20	(-1.96) **			-0.19	(-2.12) **
BSSI×EPSTD					0.12	(1.14)	0.10	(1.22)			0.10	(1.14)
BSSI×EPTOT									-0.08	(-0.89)		
Scale and scope												
ln(*SALES*)	0.50	(5.47) ***	0.50	(4.99) ***	0.53	(5.31) ***	0.43	(3.19) ***	0.35	(2.88) ***	0.50	(5.94) ***
ENTROPY	0.16	(1.52)	0.13	(1.20)	0.11	(1.00)	0.11	(0.76)	0.18	(1.33)		
Industry characteristics												
UNCER_DIF							-0.33	(-2.63) ***	-0.38	(-3.12) ***	-0.26	(-2.57) **
HHI							-0.10	(-0.82)	-0.02	(-0.13)		
IT environment												
INTERNALIT							0.22	(2.36) **	0.25	(2.61) **	0.27	(3.31) ***
SUPTECH							0.02	(0.13)	0.02	(0.19)		
SKILLREQ							-0.09	(-0.75)	-0.09	(-0.81)		
N	110		111		106		83		82		96	
R^2	0.39		0.43		0.46		0.55		0.51		0.55	
Adj. R^2	0.38		0.41		0.42		0.48		0.45		0.51	
F	22.9 ***		20.2 ***		11.8 ***		7.22 ***		7.53 ***		13.18 ***	

***p<0.01; **p<0.05, *p<0.10. Heteroskedasticity-robust variance estimator is used. All regressions contain a constant.