TO BE OR NOT TO B2B?
AN EVALUATIVE MODEL FOR E-PROCUREMENT CHANNEL ADOPTION

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ABSTRACT

With the increasing popularity of commercial uses of the Internet, business-to-business (**B2B**) e-commerce and e-procurement are moving corporate purchasing to the World Wide Web. We identify two types of B2B e-commerce business models. *Extranets* connect the buyer and its suppliers with a closed network. In contrast, *electronic markets* create open networks for buyer and supplier interactions. Extensive IS research has studied the benefits and costs of interorganizational information systems (**IOS**). Recently, we have observed a new trend towards the use of electronic markets as an alternative channel for buyers to search for and exchange supplies with a large supplier base. What are the motivations for buyers to move from extranets to electronic markets? Why is this value-maximizing for the firms? This paper develops an game theoretic economic model of this choice. The results indicate that the buyer's decision about an e-procurement approach depends on: (1) desired gains from lower search costs and operational costs enabled by an electronic market; (2) the importance of information sharing between its suppliers; (3) the extent of competition present in the supplier market; and (4) the desired levels of contractual payment transfers between buyers and suppliers.

INTRODUCTION

Broadly speaking, business-to-business (**B2B**) e-commerce involves conducting business with suppliers, customers and other companies through computer and telecommunication technologies. During the 1980s, organizations began to deploy information systems to support information sharing and communications with suppliers, distribution channels and customers (Cash and Konsynski, 1985). These IOSs started the practice of B2B e-commerce and electronic procurement, albeit outside the scope of the technological innovations associated with the Internet today. The functions of such IOSs range from simple order entry and invoicing, to product promotion, to document and data sharing, to joint product development and knowledge transfer (Johnston and Vitale, 1988; Riggins and Rhee, 1999; Chatfield and Yetton, 2000).

One important type of IOS is *electronic data interchange* (**EDI**), the business-to-business exchange of electronic documents in a standard machine-processable format. The commercialization of the Internet has brought about Internet-based EDI (also referred to as Web-based EDI). Using this mechanism, firms transmit data via the public network infrastructure instead of proprietary value-added networks or VANs (Riggins and Mukhopadhyay, 1999; Kauffman and Mohtadi, 2001). Another form of Internet-based B2B e-commerce utilizes the *extranet*, a secure, private, Web-based network, providing suppliers, customers and other business partners the access to the initiator's corporate databases, or facilitating collaborative tasks among a group of organizations (Riggins and Rhee, 1998). Via extranets, firms not only can order and purchase from suppliers, but they also can share product and sales information with each other.

Although IOSs such as EDI and extranets utilize different technologies, they share some important features with respect of business models. First, companies conduct transactions electronically on these networks. More importantly, information sharing is common between the initiator and its business partners via electronic document exchange and controlled data retrieval. Another key feature is that both are proprietary *closed network*s in the sense that these networks are only open to pre-selected business partners. Considering these characteristics, we think of these networks as one type of e-procurement channel, and use the terms "extranet" and "IOS" interchangeably in the following discussion to refer to such IT-based procurement channels.

Recently, Internet-based electronic markets have opened up another channel for corporate purchasing. Along with electronic catalogs, electronic auctions and other capabilities, electronic markets aggregate product and price information, match supply and demand, and facilitate transactions (Dai and Kauffman, 2001). Through these online markets, buyers can do one-stop, comparison shopping for thousands of suppliers and select the best source in real-time. They also can negotiate with suppliers, place orders, make payments and receive invoices. Fundamental features of these procurement

mechanisms distinguish them from extranets. They are open networks with potentially larger pools of business partners for their member firms. And they give firms more flexibility and opportunities of searching for and selecting suppliers or customers potentially resulting in more attractive pricing. On the other hand, current electronic markets are limited in supporting information sharing and collaboration between suppliers and buyers.

An important practical business process-related question facing firms in this technology investment and adoption context is: "To be or not to B2B?" More specifically, what e-procurement channel should be selected, depending on the competitive conditions, firm characteristics, and the various important qualities of the systems solutions? An extranet? Or an electronic market? And how important are network externalities? To provide insights and answers to these questions, we will develop and analyze a formal game theoretic economic model of buyers' choices in adopting either the extranet or the electronic market e-procurement channels. Our analysis focuses on understanding the factors that lead a buyer to select one e-procurement channel versus the other.

BENEFITS AND COSTS OF E-PROCUREMENT EXTRANETS AND E-MARKETS

The adoption of e-procurement systems requires the participation of multiple firms, among which certain firms will act as initiators by selecting the procurement channel and strongly encouraging their business partners to adopt the related technology. More often than not, buyers play the role of initiators and suppliers are followers. For example, Chrysler launched its EDI program in 1984 and, according to Mukhopadhyay, Kekre and Kalathur (1995), almost all its suppliers adopted this network by 1990. More recently, when big buyers start to move to online markets, they also request specific suppliers to participate to make the solution viable. Texas-based Schlumberger, for example, asked its suppliers to participate in CommerceOne's MarketSite when MarketSite was chosen as the purchasing channel for Schlumberger's office supplies (Ovans, 2000). However, buyers often find that they have to induce suppliers to join the electronic networks such as EDI systems by subsidy or punishment (Barua and Lee, 1997). More importantly, in addition to internal operational efficiencies, buyers' benefits are also related to the benefits that suppliers can appropriate, and result in significant incentives for suppliers to participate (Bakos and Brynjolfsson, 1993; Riggins and Mukhopadhyay, 1994). As a result, buyers' selection of extranets versus e-markets will depend on their own and their suppliers' costs and benefits involved in adopting e-procurement systems.

We next consider the benefits and costs of the two potential e-procurement channel choices: extranets and electronic markets. Our assessment provides a basis for formal modeling for buying firm adoption choices, in a way that reflects what we know about the literature and current industry practices.

The Buyer's Operational Efficiency. Using an electronic means for purchasing, buying companies can reduce order entry costs and inventory management costs, and at the same time get quicker responses from their suppliers. IOS efficiency benefits are generated by reduced flow time and costs of document generation and transmission, improved data integrity and fewer errors (Riggins, Kriebel and Mukhopadhyay, 1994). Mukhopadhyay, Kekre and Kalathur (1995) report on an empirical analysis of the effects of Chrysler Corporation's adoption of EDI systems. Their results show that the firm obtains approximately $100 in savings per vehicle, attributable solely to electronic document preparation and better information exchange. These savings come from reducing inventory holding costs, obsolete inventory costs and transportation costs. E-procurement systems also cut down on the time and cost of purchasing by reducing the amount of time employees spend ordering supplies and freeing them to do their jobs, as illustrated in Schlumberger (Ovans, 2000).

Supplier's Benefits. Suppliers also benefit from joining the buyer's electronic procurement network. Since the amount and nature of information shared between buyers and suppliers will greatly affect the value that suppliers can extract from the relationships (Seidmann and Sundararajan, 1997), we identify two different components of supplier benefits: *comparative efficiency* and *competitive advantage*.

Comparative efficiency comes from lower costs in producing goods or services than competitors through sharing ordering and invoicing information electronically with buyers (Johnston and Vitale, 1988). By receiving order information that is directly entered by buyers, suppliers can reduce the costs of order entry and at the same time capture data more quickly. The response time for feedback on product availability and price will also be reduced. Another benefit is that suppliers will be able to provide a lower level of customer service since buyers can shop and track orders electronically by self-service.

In addition to comparative efficiency, suppliers can obtain *competitive advantage* by joining e-procurement networks. Besides the ordering and invoicing information, buyers may also share inventory and sales data with suppliers (Seidmann and Sundararajan, 1997; Clark and Lee, 1999). Such information will enable suppliers to have more timely and accurate data for demand forecasting, promotion scheduling and production planning. With the aid of electronic communication, complex and detailed product design information also can be transferred between buyers and suppliers, enabling joint product design and development (Chatfield and Yetton, 2000). By so doing, suppliers participating in extranets will be able to accumulate expertise about market demand and product features, which usually lead to product innovation and market expansion (Subramani, 1999; Riggins and Rhee, 1999). This is a zero sum situation among competing suppliers, although it makes participants in extranets better off.

Bargaining Power Transfers. Access to the buyers' business information, including inventory management data, and product design and sales data, has the potential to increase the suppliers' bargaining power in buyer-supplier relationships. Once suppliers have such information, buyers will find

it difficult to control the use of these resources and inevitably become more vulnerable to *supplier opportunism* (Clemons, Reddi and Row, 1993). As a result, suppliers will gain bargaining advantage relative to their buyers for pricing and more beneficial contract terms. From the viewpoint of buyers, this is a cost due to sharing business information with the suppliers.

Contractual Payment Transfers. With the deployment of electronic procurement systems and information sharing, buyers and suppliers expect to enter into agreements to sustain the buyer-supplier linkage (Seidmann and Sundararajun, 1997). These agreements often ask for reduced replenishment lead time or a vendor-managed-inventory (**VMI**) program (Seidmann and Sundararajun, 1997; Lee, So, and Tang, 2000). Reducing replenishment lead time reduces buyers' inventory holding costs while increasing the supplier's logistic costs due to more frequent delivery in smaller quantity. A VMI program lets buyers to transfer costs of monitoring, holding and replenishing inventory to suppliers. As a result, suppliers tend to end up bearing that costs that buyers used to bear. Such costs are *contractual payments*: they stem from inventory or delivery management programs agreed upon between buyers and suppliers.

System Setup Costs. E-procurement systems, be they via extranets or electronic markets, require significant setup expenses when the supporting systems software is set up. For example, Waltner (1977) estimates that a typical first-time implementation of EDI systems, including hardware, software, implementation and training, costs around $50,000 (Waltner, 1997), a relatively modest expenditure. In comparison, the licensing fees for e-procurement systems using electronic markets are reported to range from a low of $1,000 to $4 million (Waltner, 1999). These costs include expenses for computer systems, system supporting personnel and training. Although the initiator typically will bear comparable setup costs in deploying either of the two e-procurement systems, followers need to have reasonable assurance that they will be able to make lower levels of investment with an e-market mechanism than with an extranet. Kauffman and Mohtadi (2001) distinguish between setup costs related to open versus proprietary e-procurement systems, and analyze situations in which firms interpret their adoption decision in terms of supply continuity and cost avoidance risks, and procurement transaction costs.

Buyer's Subsidy. In order to encourage the adoption of IOS, buyers as the initiator often subsidize suppliers to partially offset suppliers' adoption costs (Riggins, Kriebel and Mukhopadhyay, 1994; Wang and Seidmann, 1995; Barua and Lee, 1997). The subsidy takes the form of free software, system implementation assistance, employee training or financing. Riggins, Kriebel and Mukhopadhyay (1994) model a two-staged adoption process where the buyer provide subsidy at the second stage to overcome suppliers' adoption hurdle. Wang and Seidmann (1995) find that subsidizing policy is preferred when suppliers' adoption costs are high and may lead to partial adoption by the supplier base. Barua and Lee (1997) show that the optimal subsidy depends on the suppliers' technology efficiency.

Effects of Electronic Markets. Electronic markets, which are different from proprietary extranets, are *open networks* where buyers have access to a larger pool of potential suppliers with more product and price information. The aggregation and matching functions provided by electronic markets help buyers to reduce search costs and transaction costs, and as a result, buyers are more likely to receive better offers from suppliers than they can get with extranets (Bakos, 1991). In addition, previous research has shown that a larger business network attracts adopting firms due to network externalities (Kauffman, McAndrews and Wang, 2000). In our context, this makes electronic markets become an even more advantageous procurement channel for buyers.

However, in electronic markets, the level of information sharing between buyers and suppliers will be lower than in extranets due to privacy or security concerns, or the limitations of the underlying technological platforms. Ordering and invoicing information can still be exchanged through online markets. But suppliers may obtain limited information about the inventory level, and may lose access to detailed sales and product data that are sources for bargaining power and competitive value. As a result, the suppliers' bargaining advantage relative to the buyer and competitive advantage relative to its rivals will be less compared to what can be achieved with extranets.

BASIC MODEL

Seidmann and Sundararajan (1997) proposed a general framework for describing the contracting games that occur between one buyer and two suppliers in choosing levels of information sharing in supply chain management. In this paper, we extend their model to analyze decision making regarding the adoption of extranets versus electronic markets for e-procurement. We will refer to the choice of an extranet as E, and the choice of an electronic market as M in the remainder of the paper.

Let us assume that there is one relatively "big" buyer and two suppliers. The buyer is going to make a choice between an extranet and an e-market mechanism for procurement, and the suppliers will decide whether to join the buyer network. This is a simplification of the real world cases where big buyers initiate electronic procurement channels and request suppliers to participate. We also assume that the two suppliers are symmetric: that is, the benefits and costs are the same for the suppliers. As we discussed in previous sections, the buyer will obtain savings i from reduced inventory and ordering costs—operational efficiency. (See Table 1 for an overview of all the variables that we will use in our model.) No matter what type of information systems are in use, either an extranet, E, or an electronic market, M, mechanism, the buyer is able to obtain the same cost reductions that derive from improved internal efficiencies. Considering the fact that the system deployment costs incurred by the buyer firms are comparable for adopting either extranets or electronic markets, we do not include these setup costs in our model. But to a supplier as a follower in adopting the electronic procurement system, the setup costs

are usually higher when an extranet mechanism is adopted than an electronic market approach. We represent the supplier's setup cost with an extranet and an electronic market by k_E and k_M respectively. We also assume that $k_E > k_M$

Table 1. Parameter Definitions

PARAMETER NAME	DEFINITION	COMMENTS
b	Supplier benefits from bargaining power over buyer	Suggested by Clemons, Reddi and Row (1993)
c	Supplier competitive advantage (disadvantage) when only one supplier is doing business electronically with the buyer	Derived from Seidmann and Sundararajan (1997), Riggins and Rhee (1999), and Subramani (1999)
d	Discount rate, $0 < d < 1$, on competitive advantage (disadvantage) from information sharing in electronic markets relative to the extranet channel	
i	Buyer benefits from improved operational efficiency	Suggested by Mukhopadhyay, Kekre, and Kalathur (1995)
k_E, k_M	Contractual payment transfers with an extranet approach, E, or an electronic markets approach, M	We assume that $k_E > k_M$
n	Buyer's benefits from adopting an electronic market approach	Based on Bakos (1991).
q	Competitiveness in supplier market, with $0 < q < 1$	
s	Supplier's comparative efficiency	Motivated by Seidmann and Sundararajan (1997), Johnston and Vitale (1988)
S_j	Supplier j, where j $\in$ {1, 2}	For analytical tractability, we limit our analysis to just two supplier firms, as did Seidmann and Sundararajan (1997)
v_E, v_M	Contractual payment transfers with an extranet approach, E, or an electronic markets approach, M	v_{E1} and v_{E2} (v_{M1} and v_{M2}) represent how much the buyer transfers costs or provide subsidy to a supplier in its strategy to induce one supplier (either 1 or 2) to join its extranet (electronic market).
w_E, w_M	Buyer's net welfare or benefits with an extranet (electronic market) approach	w_{E1} (w_{M1}) is the buyer's net benefits when only one supplier is joining the extranet, and w_{E2} (w_{M2}) is the benefit when both suppliers are using extranets.
g	Subsidy level for adoption	Applied by buyer to suppliers in our model

In adopting the extranet approach, the supplier who is participating in the system will have access to the buyer's inventory information and will know how its product is sold, and thus the information asymmetry will be reduced (Seidmann and Sundararajan, 1997). Benefiting from this, the supplier will obtain the benefits from greater relative bargaining power, b, compared to the buyer. The buyer will think of this as receiving a payment for achieving efficiency. However, when the buyer-supplier relationship occurs in an electronic market, this value will be discounted by d, with $0 < d < 1$. This discount is due to the fact that in the market the supplier will have only limited information about how the buyer is consuming its products.

Being electronically connected with the buyer increases the supplier's ability to produce goods and services more efficiently. When only one supplier is electronically connected with the buyer, it can reap the full benefits from the cost efficiency. When both suppliers do business electronically with the buyer, this advantage is reduced by a factor of q, with $0 < q < 1$ representing the competitiveness among suppliers. When $q \to 1$, the competition is very low; in contrast, as $q \to 0$, competitive pressures become very high. If only one supplier, S_1, is using an extranet, then the supplier S_2, who is not participating, will suffer a loss in competitive position because S_1 will accumulate the knowledge and expertise for product innovation and market expansion based on its exclusive access to the buyer's proprietary information. We express the amount of this loss as c for S_2. At the same time, S_1 will obtain a benefit c. Similarly, in electronic markets, S_2 may also incur some loss because it does not have the knowledge about the buyer's demand that S_1 has. However, the amount of this loss is reduced in proportion to the degree of reduced information sharing between the buyer and S_1, i.e., S_2 will lose dc and S_1 will gain dc. With the electronic linkage, suppliers are expected to bear contractual payments v_E and v_M which are paid to the buyer.

In addition, in electronic markets the buyer will enjoy low search costs and an expanded supplier base. Moreover, the buyer will incur lower operating costs with an electronic market solution than with an extranet. We consider this as another of the benefits that is derived from adopting an electronic market mechanism. In our model, such benefits are expressed as n, which are generated only in electronic markets.

Finally, we limit our analysis to cases where the buyer will adopt either an extranet or an electronic market approach, but cannot adopt both at the same time. This assumption is applicable to cases where a buyer is considering purchasing supplies through one electronic procurement channel. For example, Dell turned off its legacy purchasing system when it implemented an e-procurement system through Ariba's marketplace for non-production supplies (Gilbert, 2000). As a result, in our model, there will be no case where one supplier is using an extranet while the other supplier is using an electronic market. Therefore, there are five possible situations requiring further analysis. (See Table 2.)

Table 2. Non-Electronic and Electronic Procurement Cases

CASE	NAME	DESCRIPTION
1	Non-Electronic	No electronic procurement approach is adopted.
2	Focal Extranet	The buyer implements an extranet involving just one supplier S_1
3	Spanning Extranet	The buyer uses an extranet to connect to both suppliers, S_1 and S_2.
4	Focal Market	The buyer purchases from one supplier S_1 using an electronic market mechanism.
5	Spanning Market	The buyer purchases from both suppliers S_1 and S_2 using an electronic market mechanism.

The buyer and suppliers' payoffs under different strategies are displayed in Figure 1. Figure 1a and 1b summarize the payoffs when the buyer chooses to adopt an extranet approach and an e-market approach, respectively. In each cell, the payoffs are displayed in the order of [S_1, S_2 and buyer]. For example, in Figure 1a, the cell in the first row and the second column has payoffs when the buyer chooses an extranet, and S_2 joins the network while S_1 does not. In this case, S_1's payoff is $-c$, S_2 obtains $b + s + c - v_E - k_E$, and the buyer obtains $i - b + v_E$.

Figure 1. Buyer and Suppliers' Payoffs

If the buyer chooses an extranet approach:

Supplier 2 \ Supplier 1	Join	Not Join
Join	$b+qs-v_E-k_E$, $b+qs-v_E-k_E$, $2i-2b+2v_E$	$-c$, $b+s+c-v_E-k_E$, $i-b+v_E$
Not Join	$b+s+c-v_E-k_E$, $-c$, $i-b+v_E$	0, 0, 0

1 (a)

If the buyer chooses an e-market approach:

Supplier 2 \ Supplier 1	Join	Not Join
Join	$db+qs-v_M-k_M$, $db+qs-v_M-k_M$, $2i-2db+2v_M+n$	$-dc$, $db+s+dc-v_M-k_M$, $i-db+v_M+n$
Not Join	$db+s+dc-v_M-k_M$, $-dc$, $i-db+v_M+n$	0, 0, 0

1 (b)

ANALYSIS OF THE BUYER'S ADOPTION DECISION

As the buyer's payoff depends on the suppliers' participation decisions, we study the buyer's adoption decision starting with an analysis of the suppliers' participation choices. Moreover, the suppliers' payoffs are closely related to the contractual payments for which the buyer has control. In this sense, the buyer can design a contracting game that leads to an optimal adoption decision.

Adopting an Extranet (E) Approach

In the case where the buyer chooses to adopt an extranet approach, the buyer can design different strategies to induce one supplier or both suppliers to participate in the network, and the buyer's payoff may be different if two suppliers join the network from if only one supplier does. Let us see how this works.

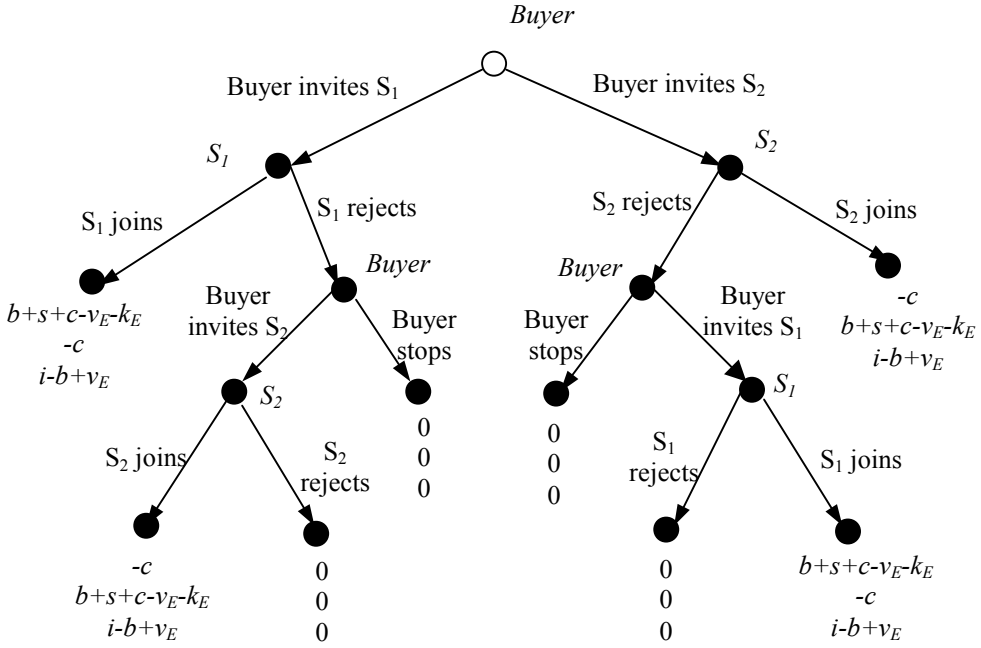
> **Proposition 1 – The Spanning Extranet Adoption Proposition**: If the contractual payment v_E satisfies $v_E < b + qs + c - k_E$, then both suppliers will adopt an extranet with the buyer.

Proof. With $v_E < b + qs + c - k_E$, joining the network becomes the dominant strategy for both suppliers. Consider the strategic form of the game depicted in Figure 1a. Since $v_E < b + qs + c - k_E$, joining the extranet gives S_1 a higher payoff than not joining, no matter whether S_2 joins the network or not. By the same token, S_2 has a higher payoff with a joining strategy. □

The *Spanning Extranet Adoption Proposition* indicates that if the buyer wants two suppliers to both join the extranet, it will not get a contractual payment from each supplier that exceeds the sum of each supplier's gain in bargaining power, the reduced gain from comparative efficiency and the gain from competitive value, less the implementation costs. If the buyer wants more contractual payment, it has to use other strategies to obtain the funding.

If the buyer wants to induce only one supplier to join the network, it can design a strategy as shown in Figure 2.

Figure 2. Extensive Form of Contracting Game That Induces One Supplier to Join the Extranet



The buyer may first try to set up a connection with one supplier, say S_1 (since the suppliers are symmetric, this arrangement will not lose generality) with a contractual payment v_{E1}. If S_1 accepts, then the buyer may stop. If S_1 rejects, then the buyer may invite S_2 to join with a contractual payment of v_{E2}. The result is as follows:

> **Proposition 2 – The Focal Extranet Proposition:** If $v_{E1} < b + s + 2c - k_E$ and $b + qs + c - k_E < v_{E2} < b + s + c - k_E$, then there will be two equivalent outcomes:
>
> (2A). The buyer invites S_1 to join the extranet with v_{E1} and S_1 accepts.
>
> (2B). The buyer invites S_2 to join the extranet with v_{E1} and S_2 accepts.

Proof. If S_1 rejects when the buyer first invites it to join, then the buyer will invite S_2 with $v_{E2} < b + s + c - k_E$. In this case the net benefit S_2 will obtain is $b + s + c - k_E - v_{E2} > 0$, and thus S_2 will agree to join the buyer extranet. As a result, S_1 will lose c. Using backward induction, it can be shown that S_1 will accept when the buyer initially invites it with v_{E1}. Since $v_{E2} > b + qs + c - k_E$, S_2 will not join after S_1 has already joined. S_1 and S_2 will <u>not</u> join together. Therefore, the outcome will be that the buyer will work with either S_1 or S_2, and the contractual payment will be $v_{E1} < b + s + 2c - k_E$. □

The buyer's net benefit will be different in Cases 2 and 3. Our examination of the conditions that will occur when the buyer makes a choice yields the following result:

> **Proposition 3 – The Buyer's Supplier-to-Extranet Connection Preference Proposition:** The buyer will select the appropriate supplier-to-extranet connections based on the following preference conditions in terms of q, a measure of the firm's competitiveness:

(3A). When $q < (k_E + s - i)/2s$, the buyer will prefer an extranet with one supplier, and its net benefit will not exceed $i + s + 2c - k_E$.

(3B). When $q > (k_E + s - i)/2s$, the buyer will prefer an extranet with both suppliers, and its net benefit will not exceed $2i + 2qs + 2c - 2k_E$.

(3C). When $q = (k_E + s - i)/2s$, the buyer will be indifferent about the number of supplier-to-extranet connections, and its net benefit will not exceed $i + s + 2c - k_E$.

Proof. The *Spanning Extranet Adoption Proposition* shows that the highest possible contractual payment the buyer can obtain is $b + qs + c - k_E$. In this case, the buyer's maximum net benefit or welfare for an extranet will be:

$$w_{E2} = 2i - 2b + 2(b + qs + c - k_E) = 2i + 2qs + 2c - 2k_E$$

The *Focal Extranet Proposition* indicates that the buyer will get a contractual payment of no more than $b + s + 2c - k_E$. This will give the buyer maximal net benefit:

$$w_{E1} = i - b + (b + s + 2c - k_E) = i + s + 2c - k_E$$

If $q < (k_E + s - i)/2s$, then

$$w_{E2} = 2i + 2qs + 2c - 2k_E < 2i + 2s*(k_E + s - i)/2s + 2c - 2k_E = i + s + 2c - k_E = w_{E1}$$

As a value-maximizing firm, the buyer will choose suppliers based on $Max\ (w_{E2},\ w_{E1})$. In this case, the buyer firm will invite only one supplier to join the extranet. Similarly, if $q > (k_E + s - i)/2s$, then $w_{E2} > w_{E1}$, and as a result, the buyer will prefer two suppliers joining the extranet. If $q = (k_E + s - i)/2s$, then $w_{E1} = w_{E2}$, and the buyer will be indifferent. □

The *Buyer's Supplier-to-Extranet Connection Preference Proposition* implies that when the level of competition in the supplier market is high, the buyer will prefer to invite one supplier to join its extranet. And when the competition is reduced to lower levels, the buyer will ask both suppliers to join the extranet. This is because an increase in competition reduces suppliers' net benefits of joining the network, and thus the buyer obtains lower contractual payment or has to pay higher subsidy to get the suppliers on board. As a result, the buyer's net benefit is reduced. Also note that when the buyer's efficiency benefits i and supplier's comparative efficiency benefits s increase, it is more likely that both suppliers will participate in the extranet. But when the supplier's implementation costs k_E are high, this will increase the likelihood that only one supplier will want to join the network. The buyer's preference is illustrated in Figure 3.

Figure 3. The Buyer's Supplier-to-Extranet Connection Preference

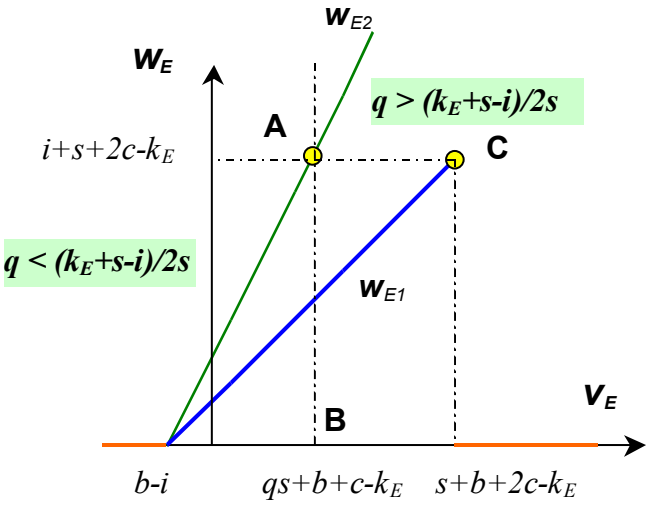


Figure 3 depicts the buyer's welfare (w_E) as a function of the supplier's contractual payment (v_E) with an extranet approach. Line w_{E1} represents the possible buyer welfare when one supplier joins the extranet, and Point C (*Vc, Wc*) shows the buyer's maximum possible welfare in this case. If both suppliers join the extranet, the buyer's welfare will fall on line w_{E2} and the maximum value is at Point A (*Va, Wa*). We are going to show how the change in q changes the maximum possible benefits the buyer can obtain with such a mechanism, with all other things being equal. This means that Point C is fixed, while Point A will move as q changes. When $q = (k_E + s - i)/2s$, A and C have the same value along the *y-axis*, which represents the buyer's welfare, i.e., $Wa = Wc$. This indicates that the buyer is indifferent about the number of connections with the suppliers. When q increases, Line AB moves to the right. That is, the buyer's welfare with two suppliers joining its extranet increases to surpass the buyer welfare when only one supplier joins, and thus A moves above C, resulting in $Wa > Wc$. This is the case when $q > (k_E + s - i)/2s$, which is represented as the area on the right of Line AB in Figure 3. In this case, the buyer will prefer a *spanning extranet strategy*. On the other hand, when $q < (k_E + s - i)/2s$, Line AB moves to the left, causing A to be lower than C, or $Wa < Wc$. That is, the buyer's maximum possible welfare is less when both suppliers join in the extranet than if only one supplier joins the extranet. This is depicted by the area on the left of Line AB. In this case, the buyer will prefer the *focal extranet strategy*. Figure 3 also shows that when the supplier's contractual payment that the buyer can obtain is less than $b - i$, the buyer's welfare will become negative, and thus it will not initiate the extranet. At the other end, the maximum supplier relationship-specific investment is $s + b + 2c - k_E$, beyond which neither supplier will agree to join the buyer extranet.

Adopting an Electronic Market (M) Approach

Now, let us examine Cases 4 and 5 where the buyer decides to use an electronic market. We offer the following proposition:

> **Proposition 4 – The Spanning Electronic Market Adoption Proposition:** If both suppliers participate in the electronic market, the supplier's contractual payment will be less than the sum of its gain from its discounted bargaining power, its gain from comparative efficiency under competition and its gain from discounted competitive value. That is, $v_M < db + qs + dc\text{-}k_M$.

Our proof is similar to that for the *Spanning Extranet Adoption Proposition* and is given in the Appendix.

Next, suppose the buyer is satisfied with the case where only one supplier participates in the electronic market. It may follow a strategy that is similar to the one it used to induce one supplier to join the extranet. That is, the buyer first tries to set up a connection with one supplier, say S_1, with a contractual payment v_{M1}. Since the suppliers are symmetric, this arrangement will not lose generality. If S_1 accepts, then the buyer may stop. If S_1 rejects, then as before, the buyer invites S_2 to join with v_{M2} as the contractual payment. The result is as follows:

> **Proposition 5 -- The Focal Electronic Market Proposition:** If $v_{M1} < db + s + 2dc\text{-}k_M$ and $db + qs + dc\text{-}k_M < v_{M2} < db + s + dc\text{-}k_M$, then there will be two equivalent outcomes:
>
> (5A). The buyer invites S_1 to join the electronic market with v_{M1} and S_1 accepts.
>
> (5B). The buyer invites S_2 to join the electronic market with v_{M1} and S_2 accepts.

The proof is similar to that for the *Focal Extranet Proposition* and also is given in the Appendix.

The buyer will compare the maximum possible net benefits it can obtain in the two electronic market cases, and make a choice as suggested by the following proposition.

> **Proposition 6 -- Buyer's Supplier-to-Market Connection Preference Proposition:** The buyer selects the appropriate supplier-to-market connections based on the following preference conditions:
>
> (6A). When $q < (k_M + s - i) / 2s$, the buyer prefers to transact with one supplier in the electronic market, and its net benefit will not exceed $i + s + 2dc + n - k_M$.
>
> (6B). When $q > (k_M + s - i) / 2s$, the buyer prefers to have both suppliers in the electronic market, and its net benefit will not exceed $2i + 2qs + 2dc + n - 2k_M$.
>
> (6C). When $q = (k_M + s - i) / 2s$, the buyer is indifferent about the number of supplier-to-market connections, and its net benefit will not exceed $i + s + 2dc + n - k_M$.

The proof for this proposition is similar to that for the *Buyer's Supplier-to-Extranet Connection Preference Proposition* and is included in the Appendix.

Based on our analysis of Cases 4 and 5, we display the buyer firm's preferences in Figure 4. (See Figure 4.)

Figure 4. The Buyer's Supplier-to-Market Connection Preference

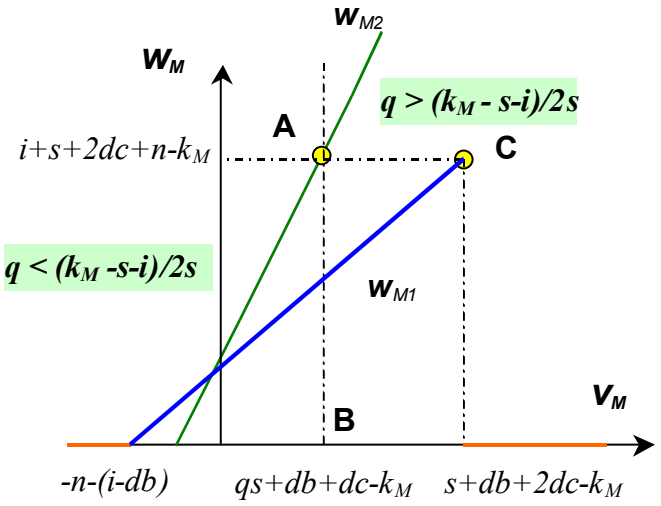


Figure 4 depicts how the buyer's welfare changes with supplier contractual payment in an electronic market. As in Figure 3, the buyer's possible welfare, when both suppliers are in the electronic market, is described by line w_{M2}, and the maximum value is indicated by point A (*Va, Wa*). When only one supplier is in the electronic market, the buyer's possible welfare is represented by line w_{M1}, and Point C (*Vc, Wc*) captures the buyer's maximum welfare. If only q changes, then Point C will be fixed and Point A may change. When $q = (k_M - s - i)/2s$, $Wa = Wc$, which means that the buyer will obtain the same maximal welfare no matter how many suppliers join the network. In this case, the buyer is indifferent about the number of connections with the suppliers via an electronic market mechanism. When $q > (k_M - s - i)/2s$, w_{M2} increases and leads Point A to be higher than Point C, i.e., $Wa > Wc$. In this case, the buyer will prefer a *spanning electronic market* with more than one supplier participant. On the other hand, when $q < (k_M - s - i)/2s$, w_{M2} decreases and thus Point A moves below Point C, i.e. $Wa < Wc$. In this case, the buyer will prefer a *focal electronic market* strategy. Figure 2 also shows that when the contractual payment that the buyer can obtain becomes less than $-n-(i-db)$, the buyer's welfare will become negative, and thus it will not initiate the electronic market. At the other end of this value spectrum, the maximum supplier contractual payment is $s + db + 2dc - k_M$, beyond which neither supplier will agree to join the buyer electronic market.

Choosing Between an Extranet and an Electronic Market

Facing these two alternatives, the buyer will compare the maximum possible net benefits it can obtain in the two arrangements and make a choice. The results of this choice are shown in the following proposition.

Proposition 7 -- The Buyer's Choice Proposition: If $n > (2 - 2d)c - (k_E - k_M)$, then the buyer will choose the electronic market approach.

Proof. Since $k_E > k_M$, the following inequality is true: $(k_E + s - i)/2s > (k_M - s - i)/2s$. Now, let us examine the following three situations that describe the extent of the suppliers' competitiveness q, via constraints on its values:

1. $q \geq (k_E + s - i)/2s$. In this case, q also satisfies $q > (k_M - s - i)/2s$. Under this condition, the maximum net benefits the buyer can obtain from adopting the extranet and the electronic market approach are w_{E2} and w_{M2}, respectively. Since $n > (2 - 2d)c - (k_E - k_M)$, we have:

$$w_{M2} = 2i + 2qs + 2dc + n - 2k_M$$

$$\geq 2i + 2qs + 2dc + (2 - 2d)c - (k_E - k_M) - 2k_M = 2i + 2qs + 2c - k_E - k_M$$

$$> 2i + 2qs + 2c - 2k_E = w_{E2}$$

Therefore, the buyer will choose an electronic market.

2. $q \leq (k_M - s - i)/2s$. This case also implies that $q < (k_E + s - i)/2s$. Under this condition, the maximum net benefits the buyer can obtain from adopting the extranet and the electronic market approach are w_{E1} and w_{M1} respectively. Since $n > (2 - 2d)c - (k_E - k_M)$, we get

$$w_{M1} = i + s + 2dc + n - k_M \geq i + s + 2dc + (2 - 2d)c - (k_E - k_M) - k_M = i + s + 2c - k_E = w_{E1}$$

Therefore, the buyer will choose electronic market.

3. $(k_M - s - i)/2s < q < (k_E + s - i)/2s$. In this case, the maximum net benefits the buyer can obtain from adopting the extranet and the electronic market approach are w_{E1} and w_{M2} respectively. The difference Δ between these two possible values is given by:

$$\Delta = w_{M2} - w_{E1} = 2i + 2qs + 2dc + n - 2k_M - (i + s + 2d - k_E)$$

$$= i + (2q - 1)s + n - (2 - 2d)c + k_E - 2k_M$$

Plugging $(k_M - s - i)/2s < q < (k_E + s - i)/2s$, we get $n - (2 - 2dc) + (k_E - k_M) < \Delta < n - (2 - 2dc) + 2(k_E - k_M)$. Thus, given that $n > (2 - 2d)c - (k_E - k_M)$, $\Delta > 0$, then $w_{M2} > w_{E1}$. Therefore, the buyer will choose an electronic market. □

So we see that the *Buyer's Choice Proposition* suggests that no matter how competitive the supplier market is, the buyer still will prefer an electronic market. This is predicated upon whether the buyer's electronic market gains from lower search costs, the expanded potential supplier base, and lower operation costs are greater than the suppliers' loss in competitive value less the suppliers' savings on system implementation. Figure 5 depicts the buyer's choice. (See Figure 5.)

Figure 5. Buyer's Choice Between the Extranet and the Electronic Market Approach

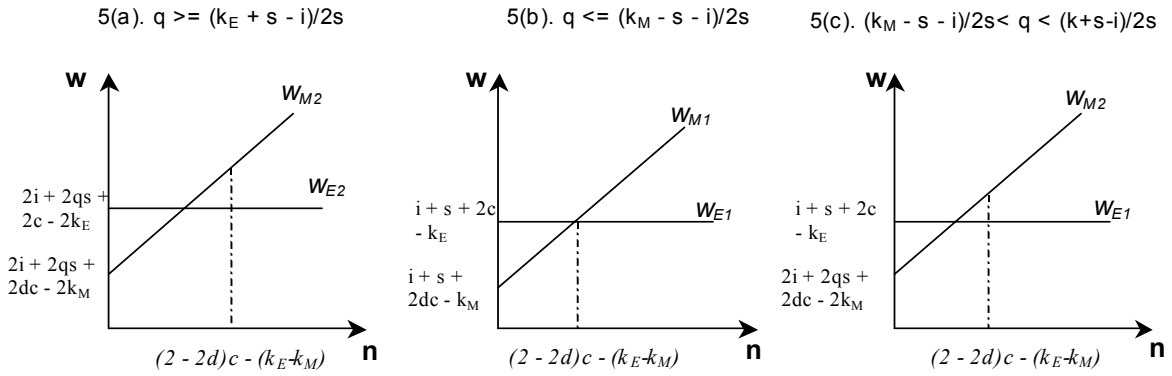


Figure 5 shows the buyer's welfare *w* as a function of its gains derived from adopting an electronic market approach in the three different supplier market competition situations 5a, 5b and 5c. When its gains from the market exceed the adoption threshold, $(2 – 2d)c – (k_E - k_M)$, the buyer will obtain higher net benefits by adopting an electronic market mechanism. Figure 5 also shows that when *d* decreases, the adoption threshold moves to the right. This implies that the buyer needs higher gains from adopting the electronic market mechanism when the reduction in information sharing has a larger impact.

ANALYSIS OF BUYER'S SUBSIDY POLICY

In this section, we discuss the circumstances under which the buyer will apply a subsidizing strategy. Previous research finds that buyers often subsidize suppliers when suppliers' setup costs are high (Riggins, Kekre and Mukhopadhyay, 1994; Wang and Seidmann, 1995; Barua and Lee, 1997). The purpose of the subsidy is to induce more suppliers to join the network. With this in mind, we will focus on the cases where the buyer tries to induce both suppliers to join the e-procurement arrangement.

We first examine the case of adopting an extranet approach. Consider a contractual payment v_E that is greater than zero. When the supplier's setup cost is high enough so that $k_E > b + c + qs$ holds, the condition under which both suppliers will join the extranet as specified in Proposition 1 will be violated. This means that the buyer cannot get both suppliers to join the extranet by adjusting the contractual payment. In this case, an appropriate alternative is for the buyer will use a subsidizing strategy.

> **Proposition 8 – The Supplier's Extranet Adoption Subsidy Proposition.** When a supplier's setup cost in joining the extranet does not exceed $i + c + (1 + q)s/2$, then the buyer may find it feasible and profitable to subsidize either one or both suppliers so that both suppliers will join the extranet.

Proof. We consider two cases in which the buyer subsidizes both and then only one supplier. See Figure 6.

Figure 6. Analysis of Buyer Subsidy for Suppliers

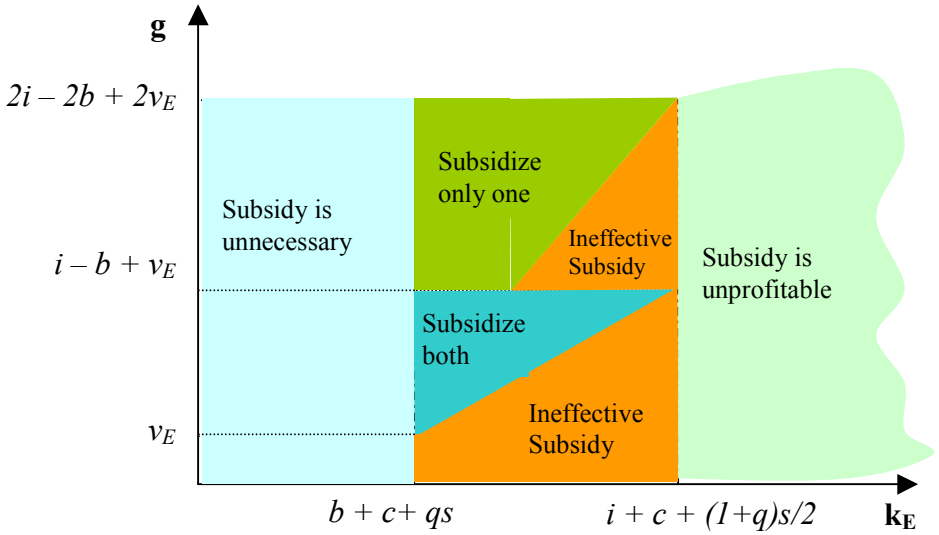


Figure 6 shows that when k_E is below a certain level, then the buyer is not required to subsidize its suppliers. However, once the supplier's setup cost goes up beyond some level, the buyer finds that the benefits from the buyer-supplier linkage cannot compensate for the costs of subsidy. In between these two cost levels, the buyer may find an amount of subsidy to induce suppliers to join the network. Let us examine the buyer's subsidizing strategies more closely now.

First, suppose the buyer subsidizes both suppliers with a subsidy g. To ensure that joining the extranet dominates not joining for both suppliers, the buyer needs to make a subsidy g that satisfies the following two conditions:

$$b + s + c - v_E - k_E + g > 0 \qquad (8\text{-}1)$$

$$b + qs - v_E - k_E + g > -c \qquad (8\text{-}2)$$

The above two conditions make sure that a supplier has a higher payoff if it joins the extranet than if it does not, no matter whether the other supplier joins or not. Rewriting Equations (8-1) and (8-2), we get

$$g > k_E + v_E - b - c - (1+q)s/2 \qquad (8\text{-}3)$$

On the one hand, the buyer's subsidy g has to satisfy inequality (8-3) so that both suppliers will prefer joining to not joining. On the other hand, the buyer should still obtain a positive payoff with a subsidizing strategy. That is, the buyer's payoff must satisfy the following condition:

$$2i - 2b + 2v_E - 2g > 0 \qquad (8\text{-}4)$$

Rewriting Equation (8-4) yields

$$g < i - b + v_E \qquad (8\text{-}5)$$

Now, we see that only when the amount of subsidy satisfies both (8-3) and (8-5) will the buyer be able to induce both suppliers to join the network while staying profitable.

Given $k_E < i + c + (1 + q)s/2$, there exists a value of the subsidy, g^*, that satisfies both (8-3) and (8-5), such that:

$$i - b + v_E > g^* > k_E + v_E - b - c - (1+q)s/2 \quad (8\text{-}6)$$

That is, when the supplier's setup cost is no higher than $i + c + (1 + q)s/2$, the buyer will find it feasible and profitable to subsidize both suppliers so that they can join the extranet.

Second, consider the case where the buyer decides to subsidize only one supplier instead of two. This occurs in a case where S_1 joins the extranet first when

$$b + s + c - v_E - k_E > 0 \quad (8\text{-}7)$$

After S_1 joins the extranet, S_2 will lose c if it does not join and will obtain $b + qs - v_E - k_E$ if it does. Since $k_E > b + c + qs$, the buyer provides subsidy to induce S_2 to join the extranet. The payoff of S_2 should satisfy:

$$b + qs - v_E - k_E + g > - c \quad (8\text{-}8)$$

Rewriting (8-7) and (8-8) yields:

$$g > 2k_E + 2v_E - 2b - 2c - (1+q)s \quad (8\text{-}9)$$

At the same time, the buyer requires a positive payoff to implement the subsidizing strategy. That is, its payoff should satisfy the following relation:

$$2i - 2b + 2v_E - g > 0 \quad (8\text{-}10)$$

Rewriting (8-10) yields:

$$g < 2i - 2b + 2v_E \quad (8\text{-}11)$$

Given $k_E < i + c + (1 + q)s/2$, there exists another value of the subsidy, g^{**}, that satisfies both (8-9) and (8-11), or:

$$2k_E + 2v_E - 2b - 2c - (1+q)s < g^{**} < 2i - 2b + 2v_E \quad (8\text{-}12)$$

That means that the buyer can induce both suppliers to join the extranet by subsidizing only one supplier. In summary, as long as the supplier's setup cost does not exceed $i + c + (1+q)s/2$, the buyer can have both suppliers join the extranet by subsidizing either one or both suppliers. □

When the buyer selects an electronic market, it can adopt a similar subsidizing strategy to induce both suppliers to join the e-procurement channel, as suggested by our final proposition.

> **Proposition 9 -- The Supplier's Electronic Market Adoption Subsidy Proposition.** When the supplier's setup cost in joining the extranet does not exceed $i + dc + (1 + q)s/2 + n/2$, then the buyer may find it feasible and profitable to subsidize either one or both suppliers so that both suppliers will join the electronic market.

(The proof for this proposition follows the logic for Proposition 8 and is included in the Appendix.)

The above analysis suggests that when the supplier's setup costs go up, the buyer is able to expand its electronic purchasing network through subsidy. However, the supplier's setup costs should not be higher than the sum of efficiency and competition benefits that are brought about by the electronic

linkage between the parties. Otherwise, the buyer will find the subsidizing strategy unprofitable. This result is consistent with Barua and Lee's (1997) finding that shows a supplier should be technologically efficient enough to attract the buyer's subsidy.

DISCUSSION

Our work offers a number of theoretical contributions for academic research on technology adoption in the e-procurement context, as well as practical implications for senior managers at firms that hope to take advantage of Internet technology who wish to make choices between adopting extranets and electronic markets for their purchasing activities.

Theoretical Contributions to Research on E-Procurement

In this paper, we draw on prior research in IOS adoption and electronic markets to analyze channel selection issues in electronic procurement. We identify two types of e-procurement channels, namely *extranets* and *electronic markets*. These differ in the extent to which the trading network is open and in the level of information sharing. Applying techniques provided by non-cooperative game theory, we analyze the strategies that firms use to choose between the two e-procurement channels. We specifically model buyer and supplier decision making in this context, and emphasize the important factors in the adoption of different procurement approaches, such as relative bargaining power, competitive advantages, operational efficiency and network effects. In investigating these factors, we emphasize the interdependence between buyers and suppliers, and the interaction among suppliers. As a result, our model shows how the supplier's adoption behavior will affect the buyer's adoption decision. Our model also exhibits the buyer's contracting and subsidizing strategies in selecting e-procurement channels. The implications we derive from this work also help us to offer guidance to senior managers in a prescriptive way. This will help them identify the contingencies under which one channel ought to be adopted versus the other. Through our analysis of this model, we are able to better understand the rationale for contemporary adoption decision making practices in the area of electronic procurement.

Among the various factors that affect firms' adoption decisions, we find that the type of information that is shared between firms has an important bearing on their relative competitive positions (Lee and Whang, 2000; Seidmann and Sundararajan, 1997). Recognizing that IT enables firms to share information across organizational boundaries and that the two e-procurement channels have different capabilities in supporting information sharing, we are able to show that a firm's channel adoption decision is affected by the channel's information sharing capability through the relative bargaining power and competitive advantage of the channel participants.

Since an important feature of the Internet is that it will potentially change how data and information flow among business partners, our analysis provides insights in addressing issues in adopting

Internet-based business processes in general, in addition to buyer's adoption of electronic procurement channels. For example, the emergence of private trading networks opens up a new form of trading channel that will supplement the capabilities of online public markets. While public markets promote open platforms and access to more potential business partners, private trading networks emphasize a high level of information sharing among business partners. Therefore, we see that our analysis in this research can be applied to understanding the adoption choices that must be made for public markets and private trading networks.

Interpreting E-Procurement Channel Adoption Decision Making

Buyer Decision Making. What do we learn about the buyer's decision making process? From the buyer's point of view, the decision will involve two levels. At the first level, the buyer makes a choice between an extranet and an electronic market approach. Our results indicate that when the buyer moves from an extranet to an electronic market, it gains the value conferred by lower search costs and lower operation costs. Such benefits vary across products and transaction types, however. Specialized products and spot purchasing will benefit more from lower search costs, while systematic purchasing benefits from lower operation costs. Therefore, if a procurement system is mainly used for systematic purchasing, then the buyer will examine the reduction in operational costs by adopting an electronic market. If a buyer expects to purchase specialized products in small quantities, it will check the various search mechanisms supported by an electronic market and the number of suppliers participating in the electronic market.

Information Sharing Effects. What are the impacts of reduced information sharing? Besides the possible gains from adopting an electronic market, the effects of reduced information sharing will also influence the buyer's preference. When the information sharing discount rate d decreases, the impetus for sharing more information will be lost by moving from extranets to electronic markets. This means that the supplier is apt to lose bargaining power relative to the buyer and thus will make a lower contractual payment. Therefore, the buyer will desire a higher return n from using an electronic market to offset benefits lost due to the reduced contractual payment.

Why Product Characteristics Matter. Are there implications that can be drawn from the kinds of products that are exchanged? We believe that the characteristics of the product purchased will affect d, the discount rate for information sharing. If the product is of low strategic value to the buyer, then the access to the information will not increase the supplier's bargaining power in an extranet channel. And so, when the supplier moves to an electronic market, reduced access to buyer information does not reduce its benefits (in other words, discount rate d will be large). As a result, the supplier will not significantly reduce its investments when they complement those of the buyer. Therefore, the buyer does not need to make a large gain from adopting an electronic market to compensate for its loss from supplier

investments. This helps to explain the large amount of online purchasing for office and operation supplies that we observe in the marketplace. These products typically are of low strategic significance to the buyer, and will cause little few concerns that lead to reduced information sharing between the buyer and its suppliers.

Implementation-Related Cost Savings. How do the supplier's cost savings affect the adoption decision? Our results suggest that the higher the supplier's cost savings due to a shift from an extranet to an electronic market, the more likely the electronic market will be adopted. The increase in the implementation costs will lead the buyer to subsidize suppliers to participate in the e-procurement network. As a result, the buyer's welfare will be reduced. Therefore, the buyer will be more likely to use an electronic market when the suppliers' cost savings are higher. This is particularly true for small suppliers. The implementation cost savings for small suppliers will greatly affect their decisions about participating in an electronic channel with the buyer.

Number of Suppliers. After deciding whether to adopt an electronic market or an extranet approach, how will the buyer decide upon the desired number of suppliers? Our model shows that, with either an extranet or an electronic market, an individual supplier's contractual payment for the buyer is higher when only one supplier joins in the electronic connection. Therefore, a buyer who wants a larger contractual payment from a particular supplier will choose to have a dedicated link with that supplier. However, the buyer's net benefits will depend on the competitiveness of the supplier market. When the competition is intense among suppliers, an individual supplier's benefits are reduced and thus it will make fewer investments for the buyer. As a result, the buyer should take into account the conditions that characterize the supplier market when it decides on the number of suppliers.

Limitations and Future Research

Our investigation of e-procurement channel adoption in this article has several limitations. *First*, to enable analytical tractability, our model is based on a market structure of one buyer and two suppliers. This helps us to focus on the buyer's adoption decision. But in reality, one buyer can set up EDI links with several (or even many) suppliers, and electronic markets can support many-to-many transactions among buyers and suppliers, as well. *Second*, the assumption of *supplier homogeneity* in the suppliers' adoption costs and benefits requires closer scrutiny. Suppliers differ in their capabilities to build electronic connections with the buyer and to integrate the external link with internal business processes. Suppliers that have more resources and can reengineer their internal and interorganizational business processes to take advantage of the electronic connections with buyers can obtain higher benefits (Lee, Clark and Tam, 1999).

Third, our model only compares two forms of electronic channels for corporate supply procurement, and does not account for other competing channels. In addition, our model does not cover

buyers' choices among similar e-procurement electronic markets, as is increasingly the case on the Internet (National Public Radio, 2000). As there often are several online B2B markets operating in one particular industry, buyers who consider adopting e-procurement systems need to evaluate the various electronic markets. *Fourth*, our model assumes that the buyer selects one channel only, but not both at the same time. Although this assumption is applicable to cases where a buyer is consolidating its purchasing through one channel, it leaves out cases where a buyer keeps both channels open. *Finally*, our model is static: that is, the adoption costs and benefits are assumed to be time invariant in our model. This implies that the decision about e-procurement channel adoption is likely to be the same at various points of time. Thus our model cannot be used to identify the *optimal time to adopt* a given e-procurement channel, even though this is often a critical element of senior management decision making in this context and other technology adoption contexts, where market changes affect the flow of potential benefits to adopters.

In future research, we will extend our model to represent more realistic market structures. In a business network with multiple buyers and multiple suppliers, *network size* is an important factor in determining the benefits for individual participants. On the one hand, the number of suppliers in a buyer extranet or an electronic market will affect each supplier's expected value for participating in the network: an *externality benefit*. Accordingly, an individual supplier's incentive to make relationship-specific investments with the buyer will be reduced when the number of suppliers in the transacting network increases: a *competition disincentive*. On the other hand, an individual buyer's expected value from a supplier network will depend on the number of participating buyers (Clemons and Kleindorfer, 1992). But in an electronic market, the more buyers there are in the market, the more attractive the online market will be to suppliers, and vice versa. Therefore, a more sophisticated model with multiple players will enable us to examine the electronic market dynamics and the equilibrium outcomes.

As an exploratory analysis, however, our model implicitly assumes that the benefits and losses are additive, leaving out the possibility of simple and complex interactions among these individual elements. We know that, in reality, these factors may influence each other. For instance, a supplier's comparative efficiency may positively influence its competitive advantage, and such an effect probably ought to be accounted for more fully in a model that aims to more fully specify the real world. Moreover, our analysis focuses on the buyer's decision to adopt e-procurement channels, and does not address the case where a supplier initiates an e-procurement program. To study how suppliers choose e-procurement mechanisms, we need to adjust the model and the analysis to more accurately portray the standpoint of a supplier.

Firms have different *absorptive capacities* that determine their benefits in adopting technology innovations of many kinds ((Cohen and Levinthal, 1989; GÖtz, 2000). To account for these differences

among firms, we should relax the assumption of *homogeneous suppliers* in our model to permit the analysis of *heterogeneous suppliers*. In addition, our model can be extended to examine the buyer's choice among competing e-procurement channels or competing electronic markets. In our specification, electronic markets differ in two ways:

- the variable *d*, information sharing support between buyers and suppliers, and,
- the variable *n*, benefits derived from lower search costs among a larger potential supplier base.

To extend our model to evaluate various electronic channels, we will elaborate on these terms and provide guidelines for selecting among electronic market choices. Finally, as system development costs can be expected to change as technologies advance over time, and the benefits derived from adopting e-procurement channels will also change over time when more firms participate in electronic markets, a *dynamic model* incorporating time-varying covariates needs to be developed in order to shed light on the question of optimal adoption timing.

In the last several decades, IT has greatly increased the options that firms have for engineering their business processes to more productively transact with their business partners. Traditional IOSs facilitate information sharing among firms, and foster closer partnerships between buyers and suppliers. However, the emerging e-procurement applications and electronic markets of the Internet provide a new alternative channel for buyers to purchase goods and services from their suppliers, in a new world of technology that few would have thought was possible only ten years ago. Faced with these additional options, senior managers at buyer firms need guidelines to make the appropriate (but hard) choices. Our intent is that this article provides insights and guidance to afford some initial steps in that direction. Although the richness of our exploratory analytical model is limited, it nonetheless provides a necessary basis for managers for understanding and comparing different adoption strategies. It also can serve as an effective starting point for future research. We expect that e-procurement systems and electronic markets will become an increasingly important corporate purchasing channel. So it is important for researchers and practitioners to develop a deeper understanding and a prescriptive framework for evaluating the various e-procurement channel choices.

REFERENCES

Bakos, J. Y. "A Strategic Analysis of Electronic Marketplaces," *MIS Quarterly* (15:3), September 1991, pp. 295-310.

Bakos, J.Y. and Brynjolfsson, E. "From Vendors to Partners: Information Technology and Incomplete Contracts in Buyer-Supplier Relationships," *Journal of Organizational Computing* (3:3), December 1993, pp. 301-328.

Barua, A., Lee, B. "An Economic Analysis of the Introduction of an Electronic Data Interchange System," *Information System Research* (8:4), December 1997, pp. 398-422.

Cash, J. I., Jr., and Konsynski, B. R. "IS Redraws Competitive Boundaries," *Harvard Business Review* (63:2), March-April 1985, pp. 134-142.

Chatfield, A. K., and Yetton, P. "Strategic Payoff from EDI As a Function of EDI Embeddedness," *Journal of Management Information Systems* (16:4), Spring 2000, pp. 195-224.

Clark, T. H., and Lee, H. G. "Performance, Interdependence and Coordination in Business-to-Business Electronic Commerce and Supply Chain Management," *Information Technology and Management* (1:1), November 1999, pp. 85-105.

Clemons, E. K., and Kleindorfer, P. R. "An Economic Analysis of Interorganizational Information Technology," *Decision Support Systems* (8:5), September 1992, pp. 431-446.

Clemons, E. K., Reddi, S. P., and Row, M. C. "The Impact of Information Technology on the Organization of Economic Activity: 'The Move to the Middle' Hypothesis," *Journal of Management Information Systems* (10:2), Fall 1993, pp. 9–35.

Cohen, W. M., and Levinthal, D. A. "Innovation and Learning: The Two Facets of R&D," *The Economic Journal* (99:397), September 1989, pp. 569-596.

Dai, Q. and Kauffman, R.J. (2001) "Business Models for Internet Based Procurement Systems and B2B Electronic Markets: An Explanatory Assessment." In Sprague, R. (Ed.), *Proceedings of the Hawaii International Conference on Systems Science*, Maui, HI, January 2001, Los Alamitos, CA: IEEE Computing Society Press, 2001. Available on CD-ROM.

Gilbert, A. "E-Procurement: Problems Behind the Promise," *InformationWeek*, Issue 813, November 20, 2000, pp. 49-57.

Götz, G. "Strategic Timing of Adoption of New Technologies under Uncertainty: A Note," *International Journal of Industrial Organization* (18:2), February 2000, pp. 369-379.

Johnston, H.R., and Vitale, M. R. "Creating Competitive Advantage with Interorganizational Information Systems," *MIS Quarterly* (12:2), June 1988, pp. 153-165.

Kauffman, R. J., McAndrews, J. and Wang, Y.M. "Opening the 'Black Box' of Network Externalities in Network Adoption," *Information Systems Research* (11:1), March 2000, pp. 61-82.

Kauffman, R. J. and Mohtadi, H. "Information Technology in B2B E-Procurement: Open Vs. Proprietary Systems," Working paper, MIS Research Center, Carlson School of Management, University of Minnesota, Minneapolis, MN, 2001.

Lee, H. G., Clark, T., and Tam, K. Y. "Can EDI Benefit Adopters?" *Information Systems Research* (10:2), June 1999, pp. 186-195.

Lee. H. L., So, K. C., and Tang, C. S. "The Value of Information Sharing in a Two-Level Supply Chain," *Management Science* (46:5), May 2000, pp. 626-643.

Lee. H. L., and Whang, S. "Information Sharing In a Supply Chain," *International Journal of Technology Management* (20:3/4), March/April 2000, pp. 373-387.

Malone, T. W., Yates, J., and Benjamin, R. I. "Electronic Markets and Electronic Hierarchies," *Communications of the ACM* (30:6), June 1987, pp. 484-497.

Mukhopadhyay, T., Kekre, S., Kalathur, S. "Business Value of Information Technology: A Study of Electronic Data Interchange," *MIS Quarterly* (19:2), June 1995, pp. 137-156.

National Public Radio. "Report on B2B Procurement Exchanges," aired on the *All Things Considered* program, National Public Radio, Washington, DC, May 23, 2000. (available via the Minnesota Public Radio website at news.mpr.org/programs/futuretense/).

Ovans, A. "E-Procurement at Schlumberger," *Harvard Business Review* (78:3), May/June 2000, pp. 21-22.

Riggins, F. J., Kriebel, C. H., and Mukhopadhyay, T. "The Growth of Interorganizational Systems in the Presence of Network Externalities," *Management Science* (40:8), August 1994, pp. 984-998.

Riggins, F. J., and Mukhopadhyay, T. " Interdependent Benefits from Interorganizational Systems: Opportunities for Business Partner Reengineering," *Journal of Management Information Systems* (11:2), Fall 1994, pp. 37-57.

Riggins, F. J., and Rhee, H-S. "Toward a Unified View of Electronic Commerce," *Communications of the ACM* (41:10), October 1998, pp. 88-95.

Riggins, F. J., and Rhee, H-S. "Developing the Learning Network Using Extranets," *International Journal of Electronic Commerce* (4:1), Fall 1999, pp.65-84.

Riggins, F. J., and Mukhopadhyay, T. "Overcoming Adoption and Implementation Risks of EDI," *International Journal of Electronic Commerce* (4:1), Summer 1999, 103-115.

Seidmann, A. and Sundararajan, A. "Building and Sustaining Interorganizational Information Sharing Relationships: The Competitive Impact of Interfacing Supply Chain Operations with Marketing Strategy," J. DeGross and K. Kumar (editors), *Proceedings of the 18th International Conference on Information Systems* (ICIS-97), Atlanta, GA, December 1997, pp. 205-222.

Subramani, M. R. "Linking IT Use to Benefits in Interorganizational Networks: The Mediating Role of Relationship-Specific Intangible Investments," P. De and J. DeGross (editors), *Proceedings of the 20th International Conference on Information Systems* (ICIS-99), Charlotte, NC, December 1999, pp. 358-363.

Waltner, C. "EDI Travels The Web -- EDI Over the Web Offers Companies Cheaper E-Commerce and Smarter Messaging Via Browsers," *CommunicationsWeek* (668), Manhasset, NY, June 16, 1997, p. 55.

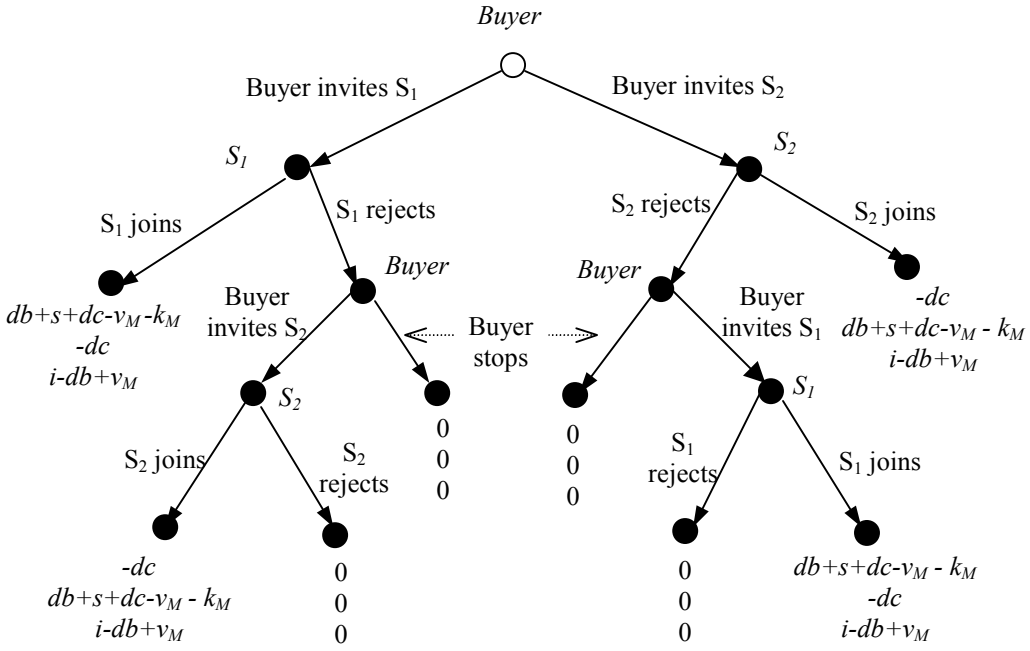
Waltner, C. "Procurement Pays Off – Companies Are Finding That Procurement Software Comes with a Quick ROI," *InformationWeek* (745), July 26, 1999 (available at www.informationweek.com/745/procure.htm).

APPENDIX OF PROOFS

Proof for Proposition 4 – The Spanning Electronic Market Adoption Proposition. With $v_M < db + qs + dc - k_M$, joining the network becomes the dominant strategy for both suppliers. Consider the strategic form game depicted in Figure 1b. Since $v_M < db + qs + dc - k_M$, joining the electronic market gives supplier 1 a higher payoff than not joining, no matter whether supplier 2 joins the network or not. By the same token, supplier 2 has a higher payoff with a joining strategy. □

Proof for Proposition 5 – The Focal Electronic Market Proposition. Figure 7 shows the buyer's contracting game for inducing one supplier to join the electronic market.

Figure 7. Extensive Form of Contracting Game That Induces One Supplier to Join an E-Market



If S_1 rejects when the buyer first invites it to join, then the buyer will invite S_2 at $v_{M2} < db + s + dc - k_M$. That gives S_2 a net benefit greater than zero, and as a rational firm, S_2 will accept. As a result, S_1 will lose dc. Considering this, S_1 will join the electronic market when the buyer initially invites it at v_{M1}. Since v_{M2} is greater than $db + qs + dc - k_M$, S_2 would not join after S_1 has already joined. That is, S_1 and S_2 will not join together. Therefore, the outcome will be that the buyer will do business via electronic market mechanism with either S_1 or S_2, and obtain contractual payment $v_{M1} < db + s + 2dc - k_M$. '

Proof for Proposition 6 -- The Buyer's Supplier-to-Market Connection Preference Proposition. The *Spanning Electronic Market Adoption Proposition* shows that the highest possible contractual

payment the buyer can obtain is $db + qs + dc - k_M$. In this case, the buyer's maximum net benefit or welfare in adopting the electronic market approach will be:

$$w_{M2} = 2i - 2db + 2(db + qs + dc - k_M) + n = 2i + 2qs + 2dc + n - 2k_M$$

The *Focal Electronic Market Proposition* indicates that the buyer will obtain contractual payment no more than $db + s + 2dc - k_M$. This will give the buyer maximal net benefit:

$$w_{M1} = i - b + (db + s + 2dc - k_M) + n = i + s + 2dc + n - k_M$$

If $q < (k_M - s - i)/2s$, then

$$w_{M2} = 2i + 2qs + 2dc + n - 2k_M < 2i + 2s*(k_M - s - i)/2s + 2dc + n - 2k_M$$
$$= i + s + 2dc + n - k_M = w_{M1}$$

As a value-maximizing firm, the buyer will choose *Max* (w_{M1}, w_{M2}). In this case, the buyer will invite only one supplier to join the electronic market. Similarly, if $q > (k_M - s - i)/2s$, then $w_{M2} > w_{M1}$, and as a result, the buyer will prefer two suppliers joining the electronic market. If $q = (k_M - s - i)/2s$, then $w_{M2} = w_{M1}$, and the buyer will be indifferent. □

Proof for Proposition 9 -- The Supplier's Electronic Market Adoption Subsidy Proposition. The proof for this proposition is analogous to what we showed earlier for Proposition 8.

First, suppose the buyer subsidizes both suppliers with subsidy g. On the one hand, to ensure that joining the electronic market dominates not joining for both suppliers, the buyer needs to choose a subsidy level g that satisfies:

$$db + s + dc - v_M - k_M + g > 0 \quad (9\text{-}1)$$

$$db + qs - v_M - k_M + g > -dc \quad (9\text{-}2)$$

Rewriting these Equations (9-1) and (9-2), we get

$$g > k_M + v_M - db - dc - (1+q)s/2 \quad (9\text{-}3)$$

In addition, the buyer's payoff must satisfy:

$$2i - 2db + 2v_M + n - 2g > 0 \quad (9\text{-}4)$$

Rewriting Equation (9-4) yields:

$$g < i - db + v_M + n \quad (9\text{-}5)$$

With $k_M < i + c + (1 + q)s/2 + n/2$, there exists a value of g, g^*, that satisfies both (9-3) and (9-5), or

$$i - db + v_M + n > g^* > k_M + v_M - db - dc - (1+q)s/2 \quad (9\text{-}6)$$

That is, when the supplier's setup cost is no higher than $i + dc + (1 + q)s/2 + n/2$, the buyer will find it both feasible and profitable to subsidize both suppliers so that they can join the electronic market.

Second, consider the case where the buyer decides to subsidize only one supplier. Suppose that S_1 joins the electronic market first without subsidy when its payoff :

$$db + s + dc - v_M - k_M > 0 \quad (9\text{-}7)$$

After S_1 joins the electronic market, the buyer subsidize S_2 to induce S_2 to join the network. S_2 will lose dc if it does not join and will obtain $db + qs - v_M - k_M + g$ if it does. For S_2 to join the electronic market, its payoff should satisfy:

$$db + qs - v_M - k_M + g > -dc \quad (9\text{-}8)$$

Rewriting Equations (9-7) and (9-8) yields:

$$g > 2k_M + 2v_M - 2db - 2dc - (1+q)s \quad (9\text{-}9)$$

At the same time, the buyer's payoff should satisfy:

$$2i - 2db + 2v_M + n - g > 0 \quad (9\text{-}10)$$

The next step is to rewrite Equation (9-10), which gives us:

$$g < 2i - 2b + 2v_E + n/2 \quad (9\text{-}11)$$

Since $k_M < i + dc + (1 + q)s/2 + n/2$, there exists a value of g, g^{**}, that satisfies both (9-9) and (9-11), or

$$2k_M + 2v_M - 2db - 2dc - (1+q)s < g^{**} < 2i - 2b + 2v_E + n/2 \quad (9\text{-}12)$$

As a result, the implication is that the buyer will induce both suppliers to join the electronic market by subsidizing only one supplier. So overall, as long as the supplier's setup cost does not exceed $i + dc + (1+q)s/2 + n/2$, then the buyer can have both suppliers join the electronic market by subsidizing either one or both suppliers. □