This article presents an economic model that enables the study of incentives for business-to-business (B2B) e-procurement systems investments which permit inventory coordination and improved operational control. We focus on the information technology (IT) adoption behavior of firms in the presence of transaction costs, agency costs and information uncertainty. But we conclude that it is appropriate to rethink the prior theory and develop an extended transactions cost theory perspective, following Clemons, et al. (1993), but with the possibility of shocks included. We distinguish among three kinds of B2B e-procurement systems platforms. Proprietary platform procurement systems involve traditional electronic data interchange (EDI) technologies. Open platform procurement systems are associated with e-markets Web technology. Hybrid platforms involve elements of both. The key drivers appear to be firm size and uncertainties that derive from the inability of a buyer firm to perfectly predict final retail demand and actual supply. We find that larger firms tend to adopt costlier solutions, but rely upon procurement technologies with more certain-to-deliver value, such as proprietary EDI. Smaller firms tend to adopt less costly procurement technologies that entail greater supply uncertainties, such as open platform procurement systems. We arrive at our findings through the specification of an analytical model that captures the key elements of our perspective—transaction costs, agency costs, information uncertainty, and shocks—and specifies the conditions under which strong conclusions can be made about the likely observed equilibrium e-procurement solutions of firms.

**KEYWORDS:** B2B, economic analysis, e-procurement, IT adoption, IT infrastructure, open platforms, proprietary platforms, procurement, risk, supply chain management, transaction costs, uncertainty.

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“Electronic commerce is a regime transition. It is now evident that the challenges of B2B e-commerce are more daunting than first imagined. More than just deliver technology, a B2B platform must address fundamental problems of strategy, cooperation, behavior, and finance. Even the simplest service—a standard transaction platform—requires enormously complex interactions.”

Quoted from SureFoods Web site, July 2001 (www.surefoods.com)

INTRODUCTION

The application of Internet technologies to supply chain management and e-procurement transactions has led to significant growth in an emerging segment of the U.S. economy in the past several years (Kumar, 2001). The Gartner Group, for example, estimated that the aggregate value of worldwide business-to-business (B2B) transactions in 2000 reached more than $433 billion, nearly three times the 1999 level. The new technologies that are being employed in electronic B2B procurement represent an IT-driven transformation of a traditional business process that needs to be better understood (Gebauer and Segev, 2000; Venkatraman, 1994).

The E-Transformation of Procurement

In spite of the early optimism (Kaplan and Sawhney, 2000), and projections of its dramatic growth (Demers, 2001; Ryback, 2001), signs were emerging as early as 2001 that the marketplace for B2B electronic market services would not be as robust as the projections (SPS Commerce, 2001). The market was projected to reach $2.2 trillion by 2003, and $7.4 and $8.5 trillion in 2004 and 2005, respectively (Mahoney, 2001). Yet no one can deny the changes that are taking place in fundamental business processes in global supply chain management (Reuters, 2001; Seidmann and Sundarajan, 1997). A report released by New York-based eMarketer.com reports that “IBM has done more than $43 billion in electronic procurement during 2000, while Boeing is now processing more than 20,000 daily transactions via its Web site” (BusinessWire, 2001). Indeed, many observers view the new technologies in this area as a “hook up or lose out” strategic value proposition (Clemons and McFarlan, 1986). Boston Consulting Group reports that by 2004, most firms that implement these kinds of technologies will save 1% to 2% of sales revenues (Forrester Research, 2001). Others recognize the extent to which the market for B2B e-market technology services is evolving (Tomak and Xia, 2002).

Among the most attractive features of B2B procurement transactions on the Internet is that buyers no longer need to make costly long-term commitments to dedicated and hard-wired proprietary procurement systems associated with proprietary solutions. (See Table 1.) Yet the available evidence points to the persistence of such proprietary procurement systems, despite the higher costs of procurement (Dai and Kauffman, 2002a), even though they were not the predominant forms for procurement platform and systems support that firms most often adopted during the last five years.
Table 1. Buyer-Supplier Firm Benefits in B2B Electronic Procurement Systems

<table>
<thead>
<tr>
<th>Supplier Benefits</th>
<th>Buyer Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small order aggregation</td>
<td>Lower cost to find/select suppliers</td>
</tr>
<tr>
<td>Lower customer acquisition costs</td>
<td>Improved negotiation due to larger orders and greater transparency</td>
</tr>
<tr>
<td>Lower transaction costs</td>
<td>Lower transaction costs</td>
</tr>
<tr>
<td>Reduced time to market</td>
<td>Diminished need to invest in supplier-focused IT infrastructure</td>
</tr>
<tr>
<td>Diminished need to invest in buyer-focused IT infrastructure</td>
<td>Reliance on market competition to establish appropriate standards, instead of third-party software solution vendor</td>
</tr>
<tr>
<td>Reliance on market competition to establish appropriate standards</td>
<td>Balanced control of technical development trajectory for the technical solution</td>
</tr>
<tr>
<td>Balanced control of technical development trajectory for the technical solution</td>
<td>Diminished concerns about information poaching by supplier</td>
</tr>
</tbody>
</table>

Source: Adapted from Transora (www.transora.com).

The procurement transaction process is at the heart of all the changes. Today, all of the parties that are typically involved in supply chain transactions believe that the importance of leveraging the capabilities of the Internet for procurement activities is critical. In this research, we will make a broad distinction between proprietary procurement systems and open platform procurement systems. Our definition of proprietary platform procurement systems pertains to those information systems capabilities developed by individual firms (especially buyers or sellers), who have an incentive to specify the software and hardware infrastructure requirements so that they best match their own procurement infrastructure or supply services infrastructure capabilities. Proprietary systems prior to the Internet were typically offered via secure dedicated lines and private networks. Pre-Internet electronic data interchange (EDI) systems constitute the most recognizable example, however, today there are still many firms that are using proprietary software together with the capabilities of the Internet in the form of Web-based proprietary EDI.¹ The key distinction that we make involves the extent to which an individual firm or a small group of firms works toward defining the exchange protocols, transaction formats, and internal operations.

¹ We thank a reviewer for pointing out that traditional EDI-based procurement systems should also be considered as part of the overall set of B2B procurement system and platform choices, since they continue to be a part of the solution mix used in industry today. Indeed, EDI-based procurement systems have traditionally been proprietary, since they required specific kinds of hardware and software solutions depending upon where they were implemented (region of the country and world, industry and product area). The spirit of EDI, however, was to focus on the development of relatively common transaction sets and communication protocols to support the mercantile exchange. This emphasis translated into relatively common database elements in the overall technical solutions that have been used among firms that chose EDI solutions, and so, in this sense at least, earlier EDI solutions share some of the characteristics of open systems solution. Today’s Internet-focused open platform procurement systems solutions go significantly beyond transaction and database design standards.
Open platform procurement systems are defined by the use of a different approach. They tend to be developed in a more neutral manner with respect to the infrastructure capabilities of buyers and suppliers, both by industry consortia and by third-party electronic intermediaries. They are observed today in market settings, where an electronic intermediary or B2B e-market firm (instead of a buyer or a supplier) develops an open platform that is intended to take advantage of the standards-based approaches of the Internet and non-proprietary (single or multiple firm-owned) e-business software capabilities.

To explain why this may be occurring, researchers have pointed to buyer-supplier coordination as a desirable property for downstream firms Barua, et al. (1995). However, there has been significant debate as to the nature of the interplay among the players (e.g., Clemons, et al., 1993; Stern and Kaufmann, 1985). Some authors argue that B2B e-commerce has the potential to change the underlying transactions costs of procurement, improving interorganizational coordination (Lee and Clark, 1996; Garicano and Kaplan, 2001). Buyer-supplier coordination is also an attractive feature of proprietary EDI systems, and this may keep firms from switching to the open B2B supply chain and procurement platforms. Delayed adoption may be reinforced by the supply risks and technology, firm and market uncertainties that are associated with this new generation of Internet-based systems support. We will argue in this article, extending the “move-to-the-middle” theory of Clemons, et al. (1993), that firms make these kinds of considerations in a manner that is consistent with a new theoretical perspective that incorporates some consideration of shocks in final demand in the retail market and upstream shocks in supply. Both reflect somewhat different aspects of uncertainty that may affect organizational decisionmaking with respect to open and proprietary platform procurement systems.

Consider the frequency of procurement purchases and the extent to which the parties involved are able to transact on a regular basis. Procurement activities may occur on a regular or irregular basis, involving the same or different trade partners. In addition, supply items whose prices are relatively stable or tend to float in a wide enough band so as to create financial risk in procurement will also affect the buyer’s perceptions of value. Other concerns relate to the potential for Internet security breaches, supply discontinuities due to the bankruptcy of a smaller on-line supplier, and procedural difficulties in financial settlement. These risks faced by the firm go beyond those that a buyer faces when she considers either a focal or a spanning strategy of engaging just a few or many suppliers. In other words, they go beyond the operational risks and opportunism risks, and the coordination costs described by Clemons, et al. (1993) as transactions costs. We consider other sources of risk that reflect exogenous shocks for the buyer in supply chain management.

Dai and Kauffman (2002a) discuss some of these tradeoffs and conclude that the success of the open platform procurement systems market, in terms of the range of technology platform connectivity that it supports, depends on the extent to which it can adapt to existing proprietary platform procurement
systems technologies. This helps to induce firms to switch platforms and still maintain reasonable costs. The authors point to some of the one-time B2B marketplace automation leaders, such as Ariba, Commerce One and i2, and their adaptability to existing EDI technologies. A recent Jupiter Research report also points to the important role of private trading networks in helping firms’ to transition from proprietary EDI systems to the new technologies of the Internet (Pelaez and Clark, 2001).

**Plan of the Paper**

The remainder of the paper is organized as follows. We next provide the background literature and referent theory that establishes our theoretical perspective. The third section presents the basic formulation of a risk-augmented transactions cost model that permits us to bring transaction costs, demand and supply uncertainty, and procurement risk into focus. The fourth section discusses the technology support context that is present in e-procurement, and discusses the difference between proprietary and open platform systems solutions. This permits us to formally analyze the model to develop the new results. The fifth section extends the fourth by considering how adoption outcomes change when there is the possibility that a prior adopter of one technology platform solution can switch to another type, as well as what happens when it is possible to have adoption of hybrid platform solutions. We also consider the managerial relevance of our propositions. We conclude by assessing the contributions and limitations of this work, and offer thoughts about some future extensions in this line of research. The emergence of co-existing networks—an important result of our model and analysis—parallels the findings of Belleflamme (1998), whose work examined network technology adoption under oligopolistic competition market structures.

**BACKGROUND THEORY AND LITERATURE**

We next consider the theoretical backdrop for the perspectives on procurement systems solutions adoption that we present in this paper.

**Transaction Costs, Risk, and Exogenous Market Demand and Supply Shocks**

We briefly compare and contrast how open and proprietary platform procurement system solutions are perceived in term of their transaction cost, financial risk, and market demand and supply uncertainties by the buyers and suppliers who invest in and participate in them. (See Table 2.) We will develop an economic model that shows how transaction cost, risks and market uncertainties are likely to lead to the co-existence, in equilibrium, of both open platform and proprietary platform procurement systems. Our primary emphasis will be on modeling the buyer’s concerns in decisionmaking. The key dependencies, as we will shortly show, are firm size and the impact of perceived market risk involving shocks in supply and demand. The dependency of a buyer’s decision about open or proprietary platform procurement systems choice on firm size arises in the context of differential transaction costs, and participants who
have different sensitivities to risk. It also is influenced by the presence of uncertainties about market demand and supply shocks.

Our model focuses on uncertainty for both the demand and supply side of procurement, and the contrasts that occur in the presence of open and proprietary systems solutions. We study how choice of information technology (IT) may reduce procurement uncertainties and, in turn, how aggregate demand side uncertainties may influence the firm’s choice of a procurement systems platform. A key emphasis is on the role of unanticipated inventories that occur due to shocks.

Table 2. Open and Proprietary Procurement Systems: Costs, Risks and Uncertainties Comparisons

<table>
<thead>
<tr>
<th>ISSUE AREAS</th>
<th>PROPRIETARY SYSTEM SOLUTIONS</th>
<th>OPEN SYSTEM SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buyer Side</td>
<td>Supplier Side</td>
</tr>
<tr>
<td></td>
<td>Costs higher than for open system solutions.</td>
<td>Costs higher for buyer search.</td>
</tr>
<tr>
<td></td>
<td>Reduces benefits of competitive market.</td>
<td>Short-term costs lower for business partners.</td>
</tr>
<tr>
<td></td>
<td>Value-sharing may diminish benefits of wider supplier search.</td>
<td>Longer-term costs may be higher, due to supplier lock-in.</td>
</tr>
<tr>
<td>Transaction costs</td>
<td></td>
<td>Lower costs for supplier search due to information and communication technology effects.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lesser need to distrust supplier’s/ e-intermediary’s technology.</td>
</tr>
<tr>
<td>Risks</td>
<td>Primary risk is inability to switch.</td>
<td>Switching ability is improved, diminishing potential cost pressure</td>
</tr>
<tr>
<td></td>
<td>Secondary risk is commitment to a proprietary infrastructure, when technology is changing.</td>
<td>Commitment risk to proprietary infrastructure is avoided.</td>
</tr>
<tr>
<td></td>
<td>Multi-period sharing of uncertainty costs. Lock-in may lead to insufficient supply. Must accede to info sharing in operations.</td>
<td>Supplier participation diminishes risk of insufficient supply. Diminution of strong ties to focal supplier unlikely.</td>
</tr>
</tbody>
</table>

Note: The contrasts shown in this table are high-level. They do not reflect the ways that ownership of a proprietary platform procurement system by a buyer or a supplier will shift the risks between the parties. Nor do they reflect governance arrangements in open platform procurement systems. We thank Qizhi Dai for suggestions on the contents of the table in light of this distinction. For a related perspective, the reader should see Han, et al. (2003), who examine issues of who should own IT in interorganizational information systems.

There are observers in the business press who suggest that the DotCom “meltdown” has served to focus many firms’ attention on operational cost reduction by reducing inventory through the adoption of more effective supply chain technologies. In 2001, *BusinessWeek* reported that “with the Internet exuberance barely cold in the grave, a far more sobering period has arrived: the era of efficiency … Today’s executives are no longer asking about technology that will help them launch new businesses but
about gear that will cut costs and wring more efficiency out of workers” (Burrows, 2001). These issues are recognized in the supply chain management context, as the example of Canada-based Celestica Inc.’s investment in proprietary supply chain management information sharing suggests. (See Text Box.)

Text Box. Demand Uncertainty and Procurement Cost Risk Sharing at Celestica, Inc.

In the past couple years, Toronto-based electronics manufacturer, Celestica Inc. (www.celestica.com), was identified by BusinessWeek magazine as being at the top of the 100 most profitable firms in the United States. The firm’s outstanding performance is attributed to its focus on inventory management in the supply chain context. For example, as the economy slowed in March 2001, the company faced a decline in demand for its products of CAN$700 million, but it was able to hold the line on excess inventory, which increased by only CAN$300 million. This outcome was achieved at a cost of CAN$60 million in supply chain management systems that “wired” its plants together across 12 different countries, enabling plant managers to see supplies and spare parts on hand, and where they might be used.

Even more interesting is that the firm fields a “Supply Chain SWAT Team” at its Toronto headquarter, which is charged with leveraging the central reporting capabilities of the firm’s supply chain system. In this instance, the SWAT Team was able to see an inventory glut developing in the system in real-time, and it used the firm’s market power with respect to suppliers to roll back pre-submitted orders based on information supplied by the system (Burrows, 2001).

This brief anecdote suggests the importance of extending the transactions costs perspective to incorporate demand and supply shocks, and why it is helpful to understand the kind of technology-based procurement solution in which the firm was willing to invest. The firm’s investment in the supply chain management system plays the dual role of a financial risk management system. Clearly, the solution that was adopted reflects a blend of considerations, including transaction costs, risk sharing, and the management of demand and supply uncertainty.

Despite the positive impression that is created by Celestica’s story, there are still numerous managerial issues and challenges. Chief among them is the issue of how the business value that accrues to IT investments in the supply chain area is split among participants, so that they can optimize their participation and investments. For example, Hwang, et al. (1993) identified initiators and followers in EDI adoption, to distinguish between firms that adopted for their own benefit and firms that were forced to adopt to achieve compliance with a strong buyer. Economics has been widely applied in IS research to understand how IT creates value (e.g., Barua, et al., 1995; Brynjolfsson and Yang, 1996; and Dos Santos and Peffers, 1995). Additional analysis has been done by economists in the network context (e.g., Economides, 1996; Farrell and Saloner, 1985; Katz and Shapiro, 1986; and Shapiro and Varian, 1999).

With the exception of the 1990s stream of research on IOS and EDI from Carnegie Mellon (e.g.,
The number of suppliers that are likely to be observed to participate in interorganizational procurement has been an important theme in IS research. For example, Riggins, et al. (1994), and Wang and Seidmann (1995) report on how marginal returns to suppliers are lower when more suppliers are involved in procurement network. Buyers, therefore, must offer incentives to induce supplier participation. This would include accepting some limitations on the number of suppliers, serving as protection against increased competition to force suppliers to offer lower prices.

Nevertheless, as the number of suppliers participating in an IOS increases, the bargaining power of participating individual suppliers declines. This diminishes their willingness to invest in systems assets and interorganizational business processes that have non-contractible elements that drive payoff (Bakos and Bryjolfsson, 1993; Raupp and Schober, 1999). In turn, this tends to exert greater pressure on the buyer firms to own cross-organizational systems assets for procurement purposes, with the result that
more outsourcing will occur. Thus, a leading prediction associated with this literature is that reduced transaction costs will lead to more interorganizational coordination (Han, et al., 2003).

Related to this is the development of increased information sharing and collaboration between buyers and suppliers, both in strategic and in operational terms, to ensure that the firms’ business processes are taking appropriate advantage of one another’s capabilities. As the foregoing discussion hints, there is likely to be greater collaboration when co-investment in the procurement system platform occurs. This will provide the infrastructure for the exchange of demand and supply forecasts, as well as information about existing inventory levels, upon which both partners can maximize the value of their respective supply chain actions. The differences that arise seem to be more related to the locus of the collaboration, rather than the absolute magnitude of collaboration we observe. In traditional procurement settings where EDI is the key means for interorganizational transaction-making, there may be an immediate incentive for the buyer to have its suppliers co-invest in IT. In an electronically-intermediated market setting, the incentive still exists, however, the locus of IT investment will shift, since buyers and suppliers both work through an intermediary. Now the locus of coinvestment for collaboration moves to two dyadic relationships: the buyer with the electronic intermediary, and the electronic intermediary with the seller.

However, one expects to observe some friction in the process. Systems integration is an important consideration between organizations and within electronic exchange environments (Truman, 2000). Dai and Kauffman (2002a) have argued that the costs for technological adaptation that foster inter-platform standards may even be unacceptably high. Also, interorganizational information sharing tends to create some discomfort even among value-maximizing partners, as Lee and Whang (2000) and Clemons and his coauthors have pointed out (Clemons and Hitt, 2004; Clemons, et al., 1993; Clemons and Row, 1992; Clemons and Weber, 2001). Thus, a critical issue is how to achieve controls for transaction risk, quality assurance and information sharing, while identifying a value-maximizing scale size for the shared business process infrastructures and activities.

Other dimensions that pose a risk to the various players are also worth pointing out. For example, an issue is the extent to which inter-firm coordination is made contractible and explicit, as opposed to loosely governed and characterized by incomplete contracts (e.g., including such considerations as product quality, timely delivery, willingness to lay off pre-specified procurement in the face of diminished demand, etc.). IOS and consortium-based e-markets often have equity sharing arrangements that involve the construction of incentives for optimal contributions by the partners. Examples include situations in which the equity ownership arrangements are favorable to the participants, with the result that larger firms may migrate towards open solutions providers who provide the right mix of inducement.

In addition, Dai and Kauffman (2002b) report on the kinds of equity and non-equity participation arrangements that arise in the strategic alliances of B2B e-markets, and note the variations in forms of
IOS governance. Ownership options constitute a key issue and driver of the outcomes that are observed, however, for the purposes of the current work we will assume no complexity around this consideration. The presence of non-contractible activities creates additional frictions in interorganizational relationships, bringing into question the extent to which the property rights of the firm are properly understood in IT investments that support exchange transactions (Grossman and Hart, 1986; Hart and Moore, 1990). Nault and Dexter (1987) have argued in favor of mechanisms that permit firms that become involved in interorganizational systems investments to recognize the critical assets that permit value to flow, and on that basis, determine ownerships and investment levels. Overall, as Clemons, et al. (1993) have argued, the market structure in electronic procurement is likely to evolve towards longer-term buyer-supplier relationships with a smaller focal group of suppliers.

**The Role of Risk and Uncertainty**

Our perspective goes beyond this already-contingent interpretation to argue that the critical driver in markets for procurement with destabilizing or already unstable demand conditions is the extent to which the firm is sensitive to risks related to the overall financial consequences of procurement. Non-contractibility in buyer-supplier relationships is the starting point for such recognition of risk. We know, for example, that as the size of the supplier network increases, the bargaining power of any individual supplier in the network will decrease (Raupp and Schober, 1999). As we have discussed, this will reduce firm-level incentives for the supplier for investing in non-contractible investments (Bakos and Bryjolfsson, 1993). If the firm faces cyclical market demand (as with automobiles), or long lead times for procurement (as with the clothing industry), the situation will typically be complicated by how a firm perceives that it is able to insulate itself from risks in the arrangements that it makes for e-procurement.

For example, consider a firm that faces stable customer demand, but views the costs of stocking out or of delivering inferior goods due, in turn, to poor supplier delivery coordination or supplier quality, to be unacceptable. This perspective may impact the firm’s willingness to engage in market-based e-procurement arrangements, if they expose the firm to an unacceptable level of uncertainty regarding the supplier’s performance. To the extent that e-procurement arrangements move firms to the lowest cost supplier, risks in delivery and quality are especially magnified.

Other considerations may be more dominant for a firm that faces highly unstable demand. Such a firm may require the supplier to share some of its risk (for example, by absorbing some of the costs associated with excess pre-contracted supplies, or changing delivery schedules, etc.). In this case, the buyer may favor a smaller number of suppliers as well, and be somewhat reluctant to procure supplies at lowest cost from suppliers who have no risk-sharing and cost absorption capacity.

In short, we argue that firms are likely to be observed to exhibit a “risk-augmented transactions cost” perspective in the choices that they make about procurement systems platforms and the buyer-supplier
arrangements that they make. Firms will account for the potential effects of investments in maximizing the value of their procurement activities, but the exact nature of the solution that is adopted will have a complex interdependence on factors beyond those that transaction costs theory, electronic markets and hierarchies theory—and even the “move to the middle” hypothesis—would suggest.

The Role of Firm Size

Firm size is recognized as an important consideration related to the performance of IT investments in modern organizations (e.g., Brynjolfsson and Hitt, 1994; Im, et al., 2001; Strassmann, 1999). Various researchers have examined IT value in a number of industries, where firm size plays an important role in moderating the business value outcomes of IT investments, including valve manufacturing (Weill, 1992), insurance (Harris and Katz, 1991), and retail banking (Dos Santos and Peffers, 1995).

There are a number of arguments to support the potential effects of firm size on technology adoption choices in the procurement systems platform context. Large firms tend to have greater access to resources. Chief among the critical resources is the managerial skill base of the organization. Strassmann (1990) conceptualizes the ability of senior managers in the firms to effectively decide upon, implement and manage IT investments in terms of “managerial productivity,” with the intention to emphasize the importance of management’s capabilities with IT. Larger organizations may have a competitive advantage for larger, more complex software projects, increasing their willingness to choose solutions for which they must bear significant cost uncertainty. In addition, organizational knowledge and technology-related competencies have sensitized IS researchers to recognize the importance of such capabilities, especially when there is rapid technological progress occurring (Winter, 1987).

Another firm size issue occurs when IT adoption decision making involves technological standards and the potential for network effects (Katz and Shapiro, 1994). Large firms have the capability to create their own intra-firm network externalities, for example, as we have seen with electronic banking networks (Kauffman, et al., 2000), the international adoption of SAP enterprise system solution approaches by large firms, as well as the adoption of open standard Web servers (Gallaugher and Wang, 2002). In addition, they also tend to benefit from having their adoption influence the choices of others, in a process that Au and Kauffman (2003) have described as rational expectations-based IT adoption decision making. But large firms still retain the ability to go their own way, committing to large-scale IT investments that they believe are in the best interests of their firms. We speculate that larger firms may be more willing, as a result, to take on proprietary systems solutions projects. In contrast, smaller firms may not have the sufficient funds for investment, and generally may express more reluctance to adopt procurement-related technology as other larger firms adopt (Iacovou, et al., 1995). Their smaller size may predispose them to select solutions with more immediate network externality benefits (Au and Kauffman, 2003) or require fewer costs for customization (Gebauer and Segev, 2002).
As we can see from the foregoing survey of the literature, the opportunity to make a new theoretical contribution lies in refining transactions cost theory—as Clemons, et al. (1993) have previously done with their “move-to-the-middle hypothesis” interpretation—relative to what should be observed when buyers have an opportunity to adopt new technologies for procurement. The contrast between our perspective and the one offered by Malone, et al.’s (1997) electronic markets and hierarchies theory and transaction costs interpretation relates to firms’ perceptions of risk in the presence of the possibility of unexpected supply and demand shocks. IT clearly impacts transactions costs for the firm. But in the presence of a number of other potential cost drivers, it is clear that senior managers of buyer and supplier firms look at other issues. They include over-supply and under-supply supply risks, technology standards and functionality risks, relationship and business partner IT co-investment risks, and exposure to other stochastic and changes in the market and competition factors. As a result, it is natural that they will modify the basis for any decision involving changes in the operation of their business process activities that are not well attuned to the nature of the risks that they have to face.

The contrast is plain. In supply chain management senior managers should be observed to adjust other aspects of their economic behavior, decisionmaking choices and IT investments beyond the predictions of Clemons, et al. (1993) relative to buyer and supplier interactions. This will occur when there are unexpected shocks to its procurement activities and there is potential for significant costs. Some shocks that may drive cost include exposure to supply chain disruption in seasonal business (i.e., “one-shot deal” procurement), unexpected exploitation of a buyers’ demand information when final demand information is shared by the buyer with the supplier, or the failure of a key supplier. There are also risks associated with insufficient quality of the procured supplies or quick shifts in demand for perishable products. Other more endogenous cost drivers include the extent of the sunk costs that are put at risk in a switch to a different procurement system platform and the size of the fixed costs that must be borne across the procurement operation. In addition, senior managers may be sensitive to the difficulties associated with technology co-investment with other firms at a scale-size that requires continuous commitment of a large amount of financial capital (i.e., uncertainty about the non-contractible aspects of interorganizational relationships). We believe that these cost drivers will change senior managers’ decisionmaking perspective towards being more focused on the risks.

There are many decisionmaking contexts in which these considerations will develop, diminishing the value of relying entirely on the predictions of transactions cost theory to understand what happens in supply chain management settings. This occurs, for example, in industries with seasonal cycles (e.g., fashion apparel, sporting goods and outdoor equipment), where the annual financial performance of the firm is largely riding on getting the procurement right and shocks have the potential to damage a year’s
financial performance. It also occurs when there is the possibility of problems with negotiating or bargaining for the benefits flows when multiple firms must be involved in making joint investments. A typical setting is financial risk management systems, where buyer-borrowers and supplier-lenders make joint investments to provide a basis for monitoring the changing risk position and creditworthiness of the borrower, and to ensure that there is up-to-date information available to support on-the-spot credit decisions. Still another context occurs when the number of required supply partners for a buyer is so large that there are scale economies and operating risks that weigh heavily on an economical solution for determining how the firm should operate. An example of this situation occurs in the personal computer industry, with firms such as Apple Computer, Dell and Gateway. These firms have so many other industry partners who supply them that it is difficult to imagine that narrow considerations about market prices for the different components that go into a computer would be value-maximizing.

This leads us to propose a risk-augmented transactions cost theory:

**DEFINITION (RISK-AUGMENTED TRANSACTIONS COSTS):** This perspective enhances the predictions of the standard transactions cost theory in supply chain management and interorganizational relationships to recognize the importance of unexpected shocks, especially technology, firm and market uncertainties (e.g., demand and supply forecast variances in supply chain management, risk and valuation variances in financial risk management, etc.). These act as drivers of observed firm behavior and outcomes in interorganizational relationships that involve, for example, IT investment, contracting and outsourcing, and organizational design and governance of shared business involvement.

To illustrate the efficacy of the new theory, we next develop and analyze a model that applies its general insights to decisionmaking for e-procurement systems platforms in supply chain management.

**AN ADOPTION DECISION MODEL FOR PROCUREMENT SYSTEMS PLATFORMS**

Early efforts to support procurement using IT emphasized management of demand uncertainty through inventory demand forecasting and reduction of inventory and transportation costs. Cycle times also were reduced through the use of optimization algorithms (Kumar, 2001). During the last decade, increases in computing power have enabled the use of these algorithms in supply chain settings, and permit firms to manage uncertainties that arise as never before. These capabilities are now being extended to the IT solutions for B2B e-commerce. Our focus is on the economics of uncertainty in the supply chain process, specifically supply and demand shocks. We next develop a model that incorporates this consideration and enables us to understand B2B procurement systems platform adoption.

**Modeling Managerial Uncertainties in Supply Chain Management**

Consider a competitive retail firm (a supply chain “buyer”) that is able to exert some price control on its products (i.e., a price setter), but faces critical demand uncertainties. We assume that the buyer procures its supplies in a competitive market subject to supply uncertainties from the supplier.

The retail electronics sector, a long-term and significant sectoral user of EDI, is a good case in point.
For example, despite competitive pressures from other firms, the retail electronics giant Best Buy boasts significant regional market share for electronics goods where it chooses to compete, permitting it to exert considerable control over its pricing and market segmentation strategies relative to other competitors. Yet, as most consumers know who have shopped at Best Buy’s superstores for DVD players and digital televisions, the firm often has insufficient stocks of these and other popular electronic products. The stock-outs stem from supply acquisition uncertainties as well as demand forecasting uncertainties.

In contexts such as this, four aspects of the buyer stand out relative to supply chain management:

- the firm’s relative market power at the product demand level;
- its competitive (price taking) behavior at the product procurement level;
- its uncertainties relative to supply; and,
- its uncertainties relative to demand.

**Demand and Supply Uncertainties.** Demand uncertainties arise from that fact that final sales are subject to unexpected shocks that the firm’s management cannot predict, so that:

\[ q_d - q_d' = \delta q_s \Rightarrow q_d' = (1 - \delta)q_s \]  

(1)

with \( \delta \sim f(0, \sigma_\delta^2) \) and \( \delta \in [-1,1] \). In this relation, \( q_d' \) is the final level of sales (or final demand, \( d_f \)), \( q_s \) is the supply quantity received from a supplier \( s \) (subject to uncertainty, as described below) and \( \delta \) is the error in management’s estimates of final demand due to random shocks. We assume that this is a relative error. Thus, we model it proportional to the magnitude of the supply (so \( \delta q_s \) is included in the right hand side.) The random variable \( \delta \) is symmetrically distributed with a distribution \( f \) that has mean 0 and variance \( \sigma_\delta^2 \). A way to ensure a lower bound on \( \delta \) is to assume that it has a truncated symmetric distribution, such as the truncated normal distribution, in the interval \([-1,1]\).

Unexpected shocks in the source of supply can be modeled in an analogous fashion, but it is relative to a control variable, \( q_o \), that represents the quantity to be ordered from the supplier.\(^2\) Thus, we write:

\[ q_s - q_o = q_o u \Rightarrow q_s = (1 + u)q_o \]  

(2)

with \( u \sim g(0, \sigma_u^2) \) and \( u \in [-1,1] \). Management’s error in estimating the supplies it can acquire is given by

---

\(^2\) Other articles on supply chain management emphasize the role of optimal order quantity policy somewhat more than we do (e.g., Cachon and Lariviere, 1999; Chen, 1998; Gavirneni et al, 1999; Lee et al., 1997; Lee et al, 2000; among others). A reviewer pointed out that the policy recommendations that flow from the single period modeling formulation that we develop may not reflect the possibility of a decreasing period order quantity. Nor will it adequately reflect the characteristics of the products that can be traded. In reality, an important potential cost that the buyer will bear is to unload excess inventory. But in a single period model, there is no market structure to permit the sale or the carry forward of inventory for sale at some discounted price. Also, there is no consideration of the interaction effects that may occur between newly-produced and second-hand, but nearly new inventory, where product and inventory type (perishable vs. non-perishable) will matter. Our translation of the cost impacts of stale inventory in one cost term is a reasonable proxy for markdowns or clearance, as well as the discounted cost-of-carry into future periods. These issues are more fully reviewed in the context of supply chain and procurement-related information sharing in other articles by Kauffman and Mohtadi (2003) and Radharkrishnan and Srindhi (2003).
\(u\), which is also a product of random shocks. The distribution \(g\) can be any symmetric truncated distribution. The source of fluctuations in the supply chain is independent of any random fluctuations in demand so that \(\text{cov}(\delta, u) = 0\). Then, the variable \(q_s\) is the control variable that management wishes to optimize (similar to what we described in the Celestica example).

The reader should note that our choice is to model the impacts of risk and uncertainty on procurement system platform adoption choice in a single period model. We justify this modeling choice in terms of the ability that we have to use order quantity levels as a proxy for firm size and the technology capital that is likely to be employed for supply chain management. We expect to obtain similar information from a short modeling horizon in terms of firm technology capital and investments in procurement systems.

**Calculating Retailer Profits.** We calculate the buyer's expected profits \(E(\pi_r)\) by integrating its objective function over the two uncertainty dimensions:

\[
E(\pi_r) = \int_{-1}^{1} g(u) du \int_{-1}^{1} \pi_r(q_s, q_d') f(\delta) d\delta
\]

(3)

In order to calculate the expected profits in Equation 3, we first evaluate the conditional expectation, \(E(\pi_r(q_s))\), which holds \(q_s\) constant but integrates over \(q_d'\), based on:

\[
E(\pi_r(q_s)) = P(q_s) q_s \cdot \text{prob}(q_s < q_d') + P(q_s) q_s \cdot \text{prob}(q_s > q_d')
- c q_s - s (q_s - q_d') \cdot \text{prob}(q_s > q_d')
\]

(4)

where, \(P(.)\) is the inverse demand function, \(c\) is the unit cost of obtaining the product from the distributor (both as a unit product cost and/or the transaction processing cost), and \(s\) is unit inventory cost. The asymmetric nature of the losses show up in two ways. *First*, they occur in the form of revenue, which is determined by whichever of the two quantities, \(q_s\) and \(q_d'\), is smaller. *Second*, they also occur as inventory costs which arise in the event of over-supply relative to final sales.

We use \(s\) to denote the inventory cost, so that storage costs are cumulative over time. (For example, in the food sector where products are perishable and in the retail sector where obsolescence matters, time is critical, and inventory costs may reach the point where they might equal or even exceed the product's price.) The parameter \(s\) is capable of representing time implicitly, if each product line is associated with a different value of \(s\). A manager of a retail firm often tracks inventory turnover for its products. Thus, different values of \(s\) can be attributed to each product as a composite of storage costs, storage time and risk of obsolescence. This is how we will interpret \(s\).

We express the probabilities in Equation 4 with \(\delta\) and its density function \(f(\delta)\) from Equation 1. Note that \(0 \leq \delta \leq 1\) when \(q_s \geq q_d'\) and \(0 \geq \delta \geq 1\) when \(q_s \leq q_d'\). Conditional expected profit in Equation 4 is:

\[
E(\pi_r(q_s)) = \int_{-1}^{0} P(q_s) q_s f(\delta) d\delta + \int_{0}^{1} P[q_s(1-\delta)] q_s (1-\delta) f(\delta) d\delta - c q_s - s \delta q_s f(\delta) d\delta
\]

(5)
This can be simplified because $q_s$ is given at this stage. This means that the term $P(q_s)q_s$ is independent of $\delta$ in the first integral. Moreover, since $f(\delta)$ is symmetric in $\delta$, and the integral covers half the range of $\delta$, the first integral can be evaluated as $(1/2)P(q_s)q_s$. We define the final term, the demand error integral, as $\Omega_\delta = \int_0^1 \delta f(\delta) \, d\delta$, so that the conditional expectation of profits is given by:

$$E(\pi_r(q_s)) = (1/2)P(q_s)q_s + \int_0^1 P[(q_s(1-\delta)) \cdot q_s(1-\delta)] f(\delta) \, d\delta - cq_s - sq \Omega_\delta$$  \hspace{1cm} (6)

**Unanticipated Over-Supply in Inventory.** In this expression, $\Omega_\delta$ represents the mean value of $\delta$, conditional on $\delta > 0$. Recall that we defined $\delta$ as the extent to which actual demand falls short of supply. Thus, $\Omega_\delta$ represents the extent to which there will be, on average, an unanticipated oversupply or inventory build-up. Since $\delta \in (0,1)$, it follows that $\Omega_\delta < 1$. Although $\Omega_\delta$ is an analytically distinct feature of $f(\delta)$, it is likely that $\Omega_\delta$ will be positively related to the variance $\sigma^2_\delta$ so that a more widespread distribution involves a larger value of $\Omega_\delta$. However, $\Omega_\delta$ contains a signal value for the extent of oversupply while $\sigma^2_\delta$ is pure white noise.

At this point, expected profits are still conditional on supply. The unconditional value of expected profits in Equation 3 is related to this conditional expectation by integrating over the supply variance $\upsilon$:

$$E(\pi_r) = \int_{-1}^1 E(\pi_r(q_s)) g(\upsilon) \, d\upsilon$$  \hspace{1cm} (7)

We can then use Equation 6, which provides an explicit form of $E(\pi_r(q_s))$. But since $q_s$ is treated stochastically now, Equation 2 is used to express $q_s$ in terms of the non-stochastic $q_o$, the retailer’s quantity of goods to be ordered up the supply chain. The resulting expression will involve the stochastic parameters $\delta$ and $\upsilon$, as arguments of the inverse demand function of $P[q_o(1+\upsilon)]$ and $P[q_o(1+\upsilon)(1-\delta)]$. As a result, further analysis must involve a Taylor series approximation of the inverse demand function, around the non-stochastic order size $q_o$ to linearize the demand function. This expansion is carried out up to the second term, and then the results can be integrated over the appropriate density functions, and simplified. Following this process, the retail firm's expected profits become:

$$E(\pi_r) \approx (1-\Omega_\delta)P(q_o)q_o - (c + s\Omega_o)q_o + q_o^2 P'(q_o)A(\sigma^2_u, \sigma^2_\delta, \Omega_\delta) \hspace{1cm} (8a)$$

where the final term is given by

$$A(\sigma^2_u, \sigma^2_\delta, \Omega_o) = (1-\Omega_\delta)\sigma^2_u + \frac{1}{2} \sigma^2_\delta (\sigma^2_\delta + \sigma^2_u) - \Omega_\delta. \hspace{1cm} (8b)$$

Notice in Equations 8a and 8b that although the supply and demand uncertainties, $\sigma^2_\delta$ and $\sigma^2_\upsilon$, affect expected profits adversely, the role of the unanticipated over-supply parameter, $\Omega_\delta$, is mixed. It affects expected profits adversely via the revenues and inventory costs (the first two terms).
But it also affects expected profits positively via the slope of inverse demand $P'(q_o)$, which is negative. This observation is tied to the market power of the retail firm. In fact for a competitive firm where demand is horizontal and $P'(q_o) = 0$, unanticipated oversupply, $\Omega_\delta$, reduces expected profits unambiguously. By contrast, firms with some market power are in a position to reduce the price level to respond to excess inventory build-up when supply exceeds sales (i.e., $q_s > q_d$, or $\delta > 0$), moderating the adverse effect of overestimating the demand. At the same time, however, the adverse effect of uncertainty, $\sigma^2_\delta$ and $\sigma^2_u$, exists only when firms enjoy some market power, but disappears otherwise. This leads us to assert the following proposition:

**PROPOSITION 1 (ADOPTING FIRM’S SUPPLY SHOCK ABSORPTION CAPACITY PROPOSITION).**

Buyers with greater market power are better able to absorb the adverse effect of oversupply shocks, by reducing prices, than those with little or no market power. They also are more adversely affected by supply and demand uncertainties than are competitive buyer firms.

To enhance the reader’s understanding of the propositions that we develop in this article, we also include an illustrative Appendix of industry examples that provide evidence for the modeling findings.

**Optimization in the Presence of Linear Demand**

As before, a retail firm will select order level $q_o$ in its supply chain to maximize expected profits. We examine the case of a linear demand (so that $P'' = 0$), where the Taylor series approximation from Equation 8a and 8b is precise. Specifically, we let $P(q_o) = a - bq_o$. A linear demand structure provides a basis for maintaining the tractability of the line of analysis that we use, and represents a reasonable way to think about the key relationships in the model. The first order condition for optimization yields:

$$
\frac{dE(\pi_c)}{dq_o} = 0 \Rightarrow q_o^* = \frac{1}{2b} \cdot \frac{(a-c)-(a+s)\Omega_\delta}{(1+\sigma_u^2)(1+\frac{1}{2}\sigma_\delta^2 - 2\Omega_\delta)}
$$  \hspace{1cm} (9a)

$$
\pi^*_c = \frac{1}{4b} \cdot \frac{[(a-c)-(a+s)\Omega_\delta]^2}{(1+\sigma_u^2)(1+\frac{1}{2}\sigma_\delta^2 - 2\Omega_\delta)}
$$  \hspace{1cm} (9b)

The denominators of Equations 9a and 9b are positive due to the concavity condition we impose to ensure optimality. As a result, a positive value of output and profit level implies that the numerator must be positive, $a(1 - \Omega_\delta) > c + s\Omega_\delta > 0$. This means the strength of the demand per unit $a$, adjusted for unanticipated oversupply, must exceed the sum of costs. The supply and demand uncertainties, $\sigma^2_\delta$ and $\sigma^2_u$, adversely affect optimum output and profits. However, the parameter $\Omega_\delta$ continues to play a dual role affecting profits and output; via the numerator it reduces both, and via the denominator it increases both. The latter effect arises from the negative slope of the inverse demand function, and shows that larger firms with market power can absorb effects of unanticipated inventory build-up by reducing prices.
IT ADOPTION IN E-PROCUREMENT: PLATFORM AND FIRM SIZE ANALYSIS

We earlier observed that different procurement strategies and the related technologies that firms must adopt do not offer the same levels of cost savings and risk avoidance. We next consider the roles of platform type (open versus proprietary) and firm size (large versus small) related to procurement systems. We will later consider hybrid platforms, which blend the other two platform types in procurement systems. Understanding the issues that they present and the responses they elicit from the firms with respect to platform adoption decisions will help us to develop additional insights about the role of transaction costs, risk perceptions and the various kinds of uncertainties that arise in procurement and supply chain management.

Proprietary Versus Open Platform Procurement Systems Adoption

To probe this further, we next extend our model by considering two forms of electronic procurement systems solutions, \( \varphi_1 \) and \( \varphi_2 \). The types of procurement systems that we discussed in the Introduction are characterized by different levels of procurement costs and supply risks:

- **Proprietary platform procurement system**: Procurement system platform \( \varphi_1 \) exposes the adopter to relatively high procurement transaction costs \( c \), but the procurement risks given by \( \sigma_u^2 \) are low because a limited number of suppliers—the “preferred suppliers” will be the focus of the interorganizational network. These firms typically have pre-existing long-term relationships.

- **Open platform procurement system**: Procurement system platform \( \varphi_2 \) causes the adopter to face relatively low procurement transaction costs, \( c \), but there are high procurement risks, as depicted by the cost variance \( \sigma_u^2 \). Even though there may be more potential suppliers, the buyer may be concerned about the potential problems when a specific source of supply has not been locked in with some certainty.

Our operationalization of proprietary versus open platform is meant to emphasize special contrasts. The variable \( \varphi_1 \) represents proprietary platform procurement systems. These include traditional EDI, and collaborative planning, forecasting and replenishment (CPFR) systems; and supplier-managed inventory (SMI) and co-managed inventory (CMI) systems. \(^3\) The variable \( \varphi_2 \) is intended to represent the first generation of open platform procurement systems that are associated with Internet-based supply chain management systems. Examples of platform vendors include Ariba, i2 and CommerceOne, prior to their moves to incorporate other firms’ proprietary software capabilities to build their suites of supply chain management software capabilities.

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\(^3\) We note that industry practices are slightly more complex. There are many instances of product sharing alliances and platform convergence strategies that bring together proprietary and open platform capabilities for supply chain management. Examples include Ariba (2001), Novopoint (2001) and Transora’s (2001) adoption of Synchra Systems Inc.’s proprietary supply chain CPFR software suite. This suggests the possibility of identifying mixed strategy technology adoption approaches. Recognizing the inherent limitations relative to real world decisionmaking, we limit ourselves to modeling pure-play technology adoption strategies.
Why do open platforms characterized by open relationships among a large number of firms entail lower procurement transaction costs than the proprietary platforms involving close relationships among few firms? We note that the costs are of two forms: *ex ante* pre-contractual search costs for finding the lowest cost supplier, and *ex post* costs of logistics, delivery, documentation and other related costs once a supplier is found. Even though it is possible that fewer suppliers (as with proprietary platforms) may mean that some components of the *ex post* costs may be lower (e.g., documentation with fewer vendors), it is clear that the *ex ante* search costs for the lowest price favors the open platform approach. Further, many components of *ex post* costs are likely to be lower for the open platforms. For example, the logistics costs of delivery are likely to be lower for open platforms because of the lower search costs to find the least costly logistics services. Finally, *ex post* enforcement and legal issues, whenever they arise, are also likely to benefit from the greater transparency of the open platform. Thus, we contend that the procurement transactions cost, $c$, will be lower for the open platforms than the proprietary platforms.

Earlier in this paper, we pointed to the possibility of uncertainties due to security problems, supply variances and discontinuities, and financial settlement risks when open platforms are selected, in spite of their broader span of market participants and possibly lower supply prices. The tradeoff between the technologies can be represented in a comparative cost-variance framework for a given level of expected profits. We can understand this trade-off through the iso-profit curve, $\bar{\Pi} \tau$, and totally differentiating Equation 9b with respect to $c$ and $\sigma_u^2$, yielding:

$$\left. \frac{d\sigma_u^2}{dc} \right|_{\bar{\Pi}} = \frac{1}{2\bar{\Pi}} \cdot \frac{1}{1+\frac{1}{2}2\sigma_u^2 - 2\Omega_s} \cdot \left[ (a-c) - (a+s)\Omega_s \right]^2$$ \hspace{1cm} (10a)

When optimum sales in Equation 9a and optimum profits in Equation 9b are positive, the slope in Equation 10a will be negative:

$$\left. \frac{d\sigma_u^2}{dc} \right|_{\bar{\Pi}} < 0$$ \hspace{1cm} (10b)

This negative slope describes a trade-off between a firm's choice of procurement systems platforms that entail lower procurement costs but a higher supply variance versus those that entail a lower procurement cost, but higher supply variance. Through marginal analysis of the second derivative of the iso-profit curve, we can find the sign of curvature of the trade-off. Differentiating Equation 10a with respect to $c$ to obtain:

$$\frac{d^2(\sigma_u^2)}{dc^2} = \frac{1}{2\bar{\Pi}} \cdot \frac{1}{1+\frac{1}{2}2\sigma_u^2 - 2\Omega_s} > 0$$ \hspace{1cm} (11)

From the signs we observe in Equations 10b and 11, we can see that the firm will face a trade-off curve that is convex to the origin, as in Figure 1.
This leads us to assert a second proposition:

**PROPOSITION 2 (PROCUREMENT RISK-TO-COST CONVEXITY PROPOSITION):** A buyer’s iso-profit curve associated with procurement system platform adoption in the parameter space of supply procurement risks versus costs is convex.

This iso-profit convexity condition suggests that firms may be able to tolerate high procurement costs or high supply variance, but, they will not be able to maintain equivalent profitability with a convex combination of both. Instead, they will need to adopt a procurement systems platform that effectively balances both to achieve high profitability.

**Differential Adoption in Large and Small Firms**

A key thread in the literature on IT value is the importance of firm size related to investment strategy and the magnitude of the returns that are achieved (Dos Santos and Peffers, 1995; Brynjolfsson and Hitt, 1994). Is firm propensity to adopt an open versus a proprietary platform procurement system also likely to depend on firm size? If so, in what new ways will this affect our interpretation of prior theory?

To answer this question we must relate firm order size to firm profits from Equations 9a and 9b:

\[
q_o^* = \frac{2\pi_r e^*}{(a-c)-(a+s)\Omega} \tag{12}
\]

Equation 12 shows that the per unit profits, \(\pi_r e^*/q_o^*\), decrease as a function of unit costs \(c\). Thus, among firms of the same size in terms of their optimal order quantities, \(q_o^*\), profits may be smaller for those with higher costs. Conversely, among the family of firms that earn the same (\(\pi_r e^*\)), and lie on the iso-profit curve shown in Figure 1, larger firms will tend to have higher unit procurement costs, based on \(q_o^*\) in Equation 12. These firms lie on the lower part of iso-profit curve of Figure 1. By the same token, among that same family of firms that earn profits, \(\pi_r e^*\), the smaller ones will tend to be those with lower...
procurement costs. They will lie on the upper part of iso-profit curve. In short, the proportionality between size (as measured by sales) and profits depends on unit procurement costs. See Figure 2.

Figure 2. B2B Platform Adoption and Firm Size

From this result, the following proposition emerges:

**PROPOSITION 3 (ADOPTING FIRM’S SELF-SELECTION PROPOSITION).** Buyers rationally self-select into different groups. Smaller buyers firms adopt procurement systems platforms that entail lower costs but higher supply variance (i.e., open platforms). Larger buyer firms adopt platforms that entail higher procurement costs but lower supply variance (e.g., the traditional proprietary platforms).

This finding generally matches what we believe has been happening in industry. The larger more established firms emphasize the maintenance of smooth supply lines by reliance on proprietary procurement systems platforms such as EDI. They keenly appreciate the extraordinary costs associated with “scrapping everything” and fully committing themselves to vendors who have yet to demonstrate they are truly able to achieve critical mass in the market. Over time, these firms’ suppliers have begun to recognize the diminution of bargaining power associated with “tied procurement systems.” For example, Strassmann (2001) cites GE’s pullback from its commitment to B2B e-commerce IT investments.

Moreover, they recognize that any significant mistake could become a “billion dollar blunder,” and

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4 Is it appropriate to include firms of different sizes in the iso-profit curve analysis shown in Figure 1? Yes, based on the related microeconomic analysis. The iso-profit curves stratify the space of all firms to the various families of firms, with each family characterized by same profit level. Technically speaking, changes in the variable $c$ enter linearly in the size Equation 9a, but quadratically in the profits Equation 9b. This is why changes in costs $c$ compensated by changes in the supply variance term $\sigma_u^2$ can leave profits in Equation 9b unchanged. This occurs along a path defined by the iso-profit curve, but can cause changes in quantity, $q^*$. So the iso-quant and iso-profit curves actually intersect. We have focused on iso-profits, not iso-quants, to control for and equalize firms’ ability to adopt IT. This approach is analogous to the approach in organizational, behavioral and economics-based empirical modeling and econometric estimation research, where there is a need to obtain a reading on a specific effect, while controlling for other related effects that may co-determine the overall outcome of interest.
require several years time for recovery. Along these lines, a 2001 *Computerworld* article comments:

“Many reasons can be traced to the limitations of the early technology. Early e-marketplaces had the most advanced technology at the time, but their applications were too costly, too complex and took too long to roll out compared with the expectations set by their B2C predecessors. This meant that potential buyers and sellers didn't participate in sufficient numbers for the model to reach critical mass and become profitable.” (Samec, 2001)

So from the point of view of a large firm, all of the concerns with respect to operational success that a small firm might face are going to be amplified—the transaction costs, the market uncertainties and the related risks. Large firms have complex operational procedures and systems, and highly specified business processes, which work in ways that are idiosyncratic to the complexities of the firm as a multi-faceted business organization. Technology adoption for core business processes goes beyond operational importance; typically whatever choices are made end up being strategic because of the extent to which operational success tends to be dependent on the quality of the associated performance outcomes. The same holds true for the market uncertainties that large firms face. With larger equity and market value at stake, a larger number of stakeholders for firm and managerial performance, and a broader set of interactions with the market, the concerns are well founded. The same goes for the technology-induced risks. Large software applications take longer to build, are more prone to implementation delays, and are more costly to implement effectively. So, in spite of the greater managerial skill base and knowledge of technology, large applications still are more susceptible to outright project failure than smaller applications. In addition, larger organizations operate with an exponentially complex network of buyers, tiered suppliers and market intermediaries, due to the spectrum of the specific supplies they must procure.

Take the example of the national United States retailer, Sears, Roebuck and Co, which has more than 6,000 suppliers. In the past four years, the firm identified a need to bring these suppliers into compliance with its own internal standards for e-commerce-capable procurement systems connectivity, to ensure control of its operating costs. A Sears spokesperson comments about the firm’s experience after contacting the e-commerce and EDI services branches of several large consulting firms, prior to the time that Sears made a decision to invest in a relationship with a “smaller, dedicated” e-commerce firm.

"The big players weren't eager to jump into an unproven business model, and their lack of enthusiasm made us wary ... It made more sense to work with a smaller firm dedicated to e-commerce, with no ancillary businesses. We wanted someone whose fortunes were tied to the quality of customer service, someone willing to stake their reputation on the quality of work they do to bring our suppliers up to speed ..." (SPS Commerce, 2001)

SPS Commerce, St. Paul, Minnesota-based software provider and consultancy, also reports that its proprietary approach has been to cover “all of the bases” for Sears, including Internet, fax, paper and application-to-application documentary exchange for B2B transactions. This is clear evidence that larger firms—and Sears is truly large—may be more willing to achieve the aim of reducing risk.

In contrast, smaller firms are willing to sacrifice supply process risks for lower procurement costs
they obtain by adopting open B2B e-commerce platforms. They have fewer “bases” to cover, and little
impetus to “recreate the wheel” with new supply chain technology solutions, but incentives to control
procurement costs. Vail Resorts, Inc., the operator of Grand Teton Lodge, and Vail, Beaver Creek and
Breckenridge ski resorts in Colorado, is a case in point. As a small enterprise and B2B e-marketplace
customer of CommerceOne, Vail Resorts has been unable to get the attention of a proprietary B2B system
provider, which, for profitability, would mostly focus on larger customers.

Our model at this point has not accounted for significant cost differences between the two types of
technologies that we have discussed. We will hold off on considering this issue in more detail until we
discuss the issue of adoption inertia. The reader should recognize, however, that the inclusion of fixed
costs will only intensify the results that we have obtained in the “Adopting Firm’s Self-Selection
Proposition.” Why? Because the costs of implementing EDI are larger than those for open platform
procurement systems. So this intensifies the relationship that the proposition depicts: large firms are the
more likely users of proprietary platforms and small firms are users of the open platforms.

ANALYZING PROCUREMENT SYSTEMS ADOPTION WITH PLATFORM SWITCHING

One of the most well known results in microeconomics characterizes adoption inertia that ensues
when a new technology is superior but presents an adopter with risks due to the variance of adoption and
implementation cost, in the presence of an older, more well-established technology that has a larger
installed base. We have seen a similar situation develop with respect to technology platforms that
support procurement. EDI is tried and true, and knowledge of how to make it work is widespread.
Moreover, EDI produces measurable value due to improvements in procurement operations (e.g., Kekre
and Mukhopadhyay, 1992; Mukhopadhyay, 1993; Mukhopadhyay, et al., 1995).

But will new platforms be perceived as having the potential to create enough value so traditional
users of EDI in supply chains make the switch? To provide insights, we model a third kind of platform.
A hybrid adaptable procurement system platform is a more technologically flexible platform, $\phi_3$. It gives
the adopter access to lower procurement transaction costs $c$, through the connectivity it offers to the
Internet. But the procurement risks given by $\sigma_u^2$ are also low, similar to the proprietary solutions.

Hybrid platform procurement solutions assure supply continuity by virtue of their adaptability in the
marketplace and their ability to cater to the larger firms' traditional customer bases. Examples of
adaptable and flexible approaches are found among some of the e-commerce technology solution industry
innovators, such as Ariba and Commerce One, as well as firms that provide logistics technologies, such as
UPS and Manugistics. An example of a buyer firm that has adopted these hybrid capabilities is CVS Inc.,
the pharmacy outlet firm, which filled more than 12% of all prescriptions in the U.S. in 2001. The firm
adopted the Ariba Buyer and Spend Management System to reduce lead times for store purchasing from
an average of seven to ten days from the store order to no more than three or four days (Ariba, 2002). The technological capabilities offered by Ariba are open platform solutions in that they are implemented in the Web context, and also proprietary platform solutions in that the management functions that they support are made possible by software tools that are unique to Ariba. In addition, recently Business 2.0 (Schonfeld, 2002) reported on IBM’s ambitious new systems approach for integrating clients’ diverse technologies, based on open platform, open source technologies such as Java and Linux. This way, IBM is able to adapt to the client’s traditional proprietary systems, making the procurement system a hybrid adaptable platform implementation.

We next consider the impacts of introducing this new kind of technology in the marketplace in the context of our risk-augmented transactions cost theory. (See Figure 3.)

**Figure 3. Adaptability Impact of a Hybrid Platform Procurement System**

The figure shows that both large and small firms will have an incentive to move to this technology, as this implies a higher iso-profit curve, i.e., an IT investment frontier that corresponds to a higher profit level for the hybrid platform solution adopter. Thus, we expect that firms are likely to cluster around the new, more adaptable form of technology, as depicted in the figure. This result can be summarized as:

**Proposition 4 (Hybrid Platform Procurement System Adoption Proposition).**

The emergence of a more adaptable hybrid platform that reduces both procurement costs and supply uncertainty will attract both large and small buyers, and will dominate both the proprietary and the open platforms.

This proposition reflects in a realistic way what we currently are seeing in the market, with the movement of firms to technology solutions that blend elements of the old with elements of the new platforms. In addition to the dimensions that we have focused on in this analysis, supply variance and procurement cost, it is natural to recognize that the added flexibility inherent in hybrid platform technology offers value of its own to the adopting firm. Although we do not model this option value of
the potential flexibility benefits, it seems obvious to us that the attractiveness of this kind of solution should go beyond the narrow value bounds that we describe. Indeed, it cannot be worth less.

**Adoption Inertia**

Although a hybrid platform procurement systems solution offers “win-win” possibilities in terms of reduced procurement costs and reduced supply variance, a firm with a large installed base and large investments in an existing technology may require a greater incentive in order to switch to the new hybrid technology than would be the case for a firm with smaller sunk costs. But if the gains from such systems changes are large enough, they can overcome such adoption inertia and persuade the management that a switch to the new technology is timely. Our model not only explains this behavior, but it also quantifies the “threshold level” of the new technology, in terms of procurement cost-procurement risk parameters at which firms will overcome this inertia so that switching occurs.

Following up on the structure of our prior model, consider two states of the world. In State 1 the firm has available a procurement systems platform such as $\phi_1$ or $\phi_2$, but is considering moving to State 2, characterized by a new platform $\phi_3$ with lower procurement costs, $c$, and procurement risks, $\sigma_u^2$, than either $\phi_1$ or $\phi_2$. However, adopting $\phi_3$ involves both the fixed cost of the new platform, say $F_{NEW}$, plus the transition costs associated changing over from and dismantling the old technology, say $F_{OLD}$. These transitional costs may be significant and entail direct costs associated with retraining, reorganization, as well as indirect costs associated with productivity loss due to the transition. From Equation 9b, the states are:

$$(\pi^*_{STATE_1}) = A[c_{STATE_1}, (\sigma_u^2)_{STATE_1}]$$ (13a)

$$(\pi^*_{STATE_2}) = A[c_{STATE_2}, (\sigma_u^2)_{STATE_2}] - r(F_{NEW} + F_{OLD})$$ (13b)

where $A(c, \sigma_u^2)$ is a function, decreasing in both $c$ and $\sigma_u^2$, given by the right hand side of Equation 9b and $r(F_{NEW} + F_{OLD})$ is the amortized value of costs, assuming a long time horizon.5

So the switch to the new technology occurs if $(\pi^*_{STATE_2})$ is at least as large as $(\pi^*_{STATE_1})$, or,

$$A[c_{STATE_2}, (\sigma_u^2)_{STATE_2}] - A[c_{STATE_1}, (\sigma_u^2)_{STATE_1}] \geq r(F_{NEW} + F_{OLD})$$ (14)

By assumption, the procurement systems platform in State 2 is superior to that in State 1. Thus, $A[c_{STATE_2}, (\sigma_u^2)_{STATE_2}] > A[c_{STATE_1}, (\sigma_u^2)_{STATE_1}]$ and the left side of Equation 14 is positive. But will the gains from switching to the new platform be large enough to induce the firm to switch? Clearly, the larger are the costs associated with the new platform, the more difficult it will be. One likely factor

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5 State 1 does not entail any fixed costs. We assume the technology platform has been in place and any future fixed costs and remaining costs are small. Adding such costs to the model adds no new insights. For example, it would be easy to subtract any such remaining costs in State 1. However, such costs would be carried into State 2, as the firm’s continuing financial obligations. But the profit differential between the two states will be equal.
influencing the size of the transition costs is the degree to which the previous system is integrated into the firm’s organization. In addition, some other considerations also may play a role, for example, relationships with the firm’s clients, and the distinctive qualities of the State 1 platform compared to the State 2 platform. These issues suggest that traditional proprietary procurement systems such as EDI are likely to entail greater transition costs:

\[ F_{OLD}(\varphi_1) > F_{OLD}(\varphi_2) \]  

(15)

Thus, adoption from these legacy systems to the hybrid platform will encounter larger inertia. Figure 4 shows this result. (See Figure 4.) Firms that have already adopted the proprietary technology, \( \varphi_1 \) (e.g., EDI), will face greater inertia in converting to the hybrid technology solution, \( \varphi_3 \). This is seen by firms that bypass the iso-profit curve on which \( \varphi_3 \) lies, which does not offer sufficient superiority to overcome the adoption inertia. But \( \varphi_3^{SUPERIOR} \), in contrast, is sufficiently attractive to ensure adoption even by these firms. Firms that have previously adopted \( \varphi_1 \), such as an open platform procurement system, will adopt either \( \varphi_3^{INFERIOR} \) or \( \varphi_3^{SUPERIOR} \).

**Figure 4. Procurement System Platform Adoption Inertia**

Supply Variance

\[ (\pi_r^*)_{STATE,1} = A[c_{STATE,1}, (\sigma_u^2)_{STATE,1}] \]

\[ A[c_{STATE,1}, (\sigma_u^2)_{STATE,1}] + r(F_{OLD} + F_{NEW}) > A[c_{STATE,2}, (\sigma_u^2)_{STATE,2}] > A[c_{STATE,1}, (\sigma_u^2)_{STATE,1}] \]

So \( \varphi_3^{SUPERIOR} \), the hybrid platform, is superior.

\[ A[c_{STATE,1}, (\sigma_u^2)_{STATE,1}] + r(F_{OLD} + F_{NEW}) > A[c_{STATE,1}, (\sigma_u^2)_{STATE,1}] > A[c_{STATE,2}, (\sigma_u^2)_{STATE,2}] \]

So \( \varphi_3^{INFERIOR} \), the hybrid platform, is not superior.

Demand Variance

Demand variance is represented by the second uncertainty parameter, \( \sigma_u^2 \). To understand the effect of this parameter on the trade-off relationship between cost \( c \) and supply variance \( \sigma_u^2 \), note that in

\[ \frac{d}{d\sigma_u^2} \frac{d\sigma_u^2}{dc} \big|_{\pi_r} > 0 \] and \[ \frac{d}{d\sigma_u^2} \frac{d^2\sigma_u^2}{dc^2} \big|_{\pi_r} < 0 \]. Moreover, the profit
Equation 9b shows that profits, \( \pi_r^e \), fall in \( \sigma^2 \). These results indicate that the iso-profit curve shifts out and becomes flatter as it shifts, as we show in Figure 5. (See Figure 5.) This leads us to assert:

**Proposition 5 (Demand Variance Proposition):** As the buyer’s profits fall with higher demand uncertainty, the trade-off between costs and supply variance shifts in favor of giving greater weight to the role of supply variance (indicated by the nature of the “tilt” in the shifting of the iso-profit curve).

**Figure 5. The Shift of Buyer’s Procurement Systems Platform Adoption Iso-Profit Curve**

So demand variance reflects the degree of market uncertainty. And it plays an important role in the firm’s decision process of whether to adopt a certain platform. We analyze the firm’s procurement system platform decision in this case, by revisiting some of the findings in an earlier subjection on the criteria for platform adoption. Consider, as before, a firm currently that currently owns a legacy system platform for procurement is considering whether to adopt a superior platform, such as a hybrid platform solution, \( \phi_3 \). This decision is impacted when issues of demand uncertainty arise. In this case, the left hand side of the inequality in Equation 14, \( A[c_{STATE,2},(\sigma_u^2)_{STATE,2}] - A[c_{STATE,1},(\sigma_u^2)_{STATE,1}] \), depends on the size of demand uncertainty, \( \sigma^2 \). We can verify from the profit Equation 9b that its value falls as \( \sigma^2 \) rises, i.e., \( \frac{dA[c_{STATE,2},(\sigma_u^2)_{STATE,2}] - A[c_{STATE,1},(\sigma_u^2)_{STATE,1}]}{d\sigma^2} < 0 \). In the context of Equation 14, we find another interesting result, which we state as our final proposition:

**Proposition 6 (Demand Variance-Procurement Systems Platform Adoption Proposition):** Higher demand uncertainty reduces a buyer firm’s incentive, on average, to adopt new technologies.

In general, demand variances create instabilities in the revenue and cost flows of the buyers. The higher the demand variance, the greater will be the risk and exposure of the buyer to the possibility of
financial loss. Why? When demand variances occur—especially in terms of stocking out in the presence of high demand—the buyer is forced to go to the spot market to replenish stock, with the likelihood that it will experience unfavorable prices. This gives the buyer more incentive to create long-term contracts and other B2B arrangements to buffer it from higher costs. Spot buying will not be nearly as attractive, diminishing a buyer’s willingness to go into an e-procurement market. The same outcome is true on the low demand side. With excess inventories, a buyer will be forced to bear the fixed costs of procurement, which include the procurement system platform expenses, as well as the vendor management costs and the costs of the relationship with an electronic intermediary.

DISCUSSION

Our analysis in this paper has important implications for the managerial selection of IT platforms in the context of e-procurement. Our first proposition, the “Adopting Firm’s Supply Shock Absorption Capacity Proposition,” suggests that a firm’s ability to absorb the disadvantageous effects of random over-supply shocks is founded on its market power and capacity to set prices. This also suggests the structure of the market in which the adoption decision for e-procurement platform technologies occurs, creating a basis of expectations for the buyer firm’s management relative to the kinds of impacts that a B2B e-procurement should have. Irrespective of the specific choice, if the firm is able to reduce prices and increase sales, then its incremental revenues are likely to ameliorate the negative consequences of sudden over-supply. In contrast, we learned that the effects of greater uncertainties with respect to both demand and supply shocks may have greater consequences for firms with more market power.

We also noted that the iso-profit curve associated with the trade-off between procurement risk and procurement cost is convex for the adoption of a B2B e-market platform procurement technology decision. Our second proposition, the “Procurement Risk-to-Cost Convexity Proposition,” informs managerial decisionmakers that their platform choices should be viewed in terms of the relative risk-to-cost balance that is achieved. Along this procurement risk-procurement cost iso-profit curve, the differences in the impacts of the procurement platform adoption choices materialize. Our third proposition, the “Adopting Firm’s Self-Selection Proposition,” suggests the different perspectives of large and small firms. Since small firms face critical constraints on their spending for infrastructure development, they will spend fewer dollars to create their e-procurement technology platform solutions, and be willing to accept the higher supply variances that emerge from procuring supplies in a public or private exchange market setting. When the opportunity to switch to another e-procurement platform arises, it is natural for the firm to seek solutions that reduce both procurement costs and the uncertainty of supplies. In recent years, we have been seen such opportunities come to the marketplace, as the emerging technical solutions that are based on open source technologies are increasingly integrated to reduce
adopter costs while still providing connectivity between buyers and suppliers.

Our fourth proposition, the “Hybrid Platform Procurement System Adoption Proposition,” posits that such emerging solutions will attract both large and small firms, in spite of their being affected by shocks in demand and supply. However, accompanying the new potential for value associated with such solutions is the possibility that the sunk costs invested in a prior solution (e.g., standard EDI, Web-based EDI, etc.) may create friction on the part of firms that may consider moving to the hybrid technology. This is also natural, since there are inevitably risks that occur with implementation and systems integration. However, the perspective that we offer is aimed at analyzing and potentially influencing the behavior that firms exhibit as they estimate the threshold level of business value that makes switching economical. Our fifth proposition, the “Demand Variance Proposition,” points out why larger firms will be in a better position to bear the effects of excess inventory, based on their unit production and unit inventory costs relative to smaller firms. The final proposition, the “Demand Variance-Technology Adoption Proposition,” points out that the link between the effects of high demand variance and the impacts that are likely to be felt by buyers diminishes the impetus of the buyer to adopt new technology. This will tend to diminish adoption of the open platform and hybrid platform technology choices.

In our analysis, we distinguished between the switch from older systems and newer open standard and hybrid procurement technology solutions. We argued that the greater the infrastructure updating cost, the greater will be the extent of the inertia that will need to be overcome before a firm will make a switch. In this context, technology vendors must appreciate the fact that subsidies are potentially necessary for platform updating to occur to maximize total benefits for all parties involved, as noted earlier by Riggins, et al. (1994). Yet the marketplace has been difficult, making it harder even for the reasonably well-established players to find the slack resources to subsidize other players. Indeed, many observers would argue that the primary subsidies in this industry sector have come from venture capitalists, who have yet to realize any real returns on the significant sums of money they have spent during the last five years. The fact that the economy has not been in a stable growth mode only compounds the difficulties that the technology solution vendors are facing in having their procurement systems platforms solutions adopted.

CONCLUSIONS

In this article, we modeled the trade-offs in the choices that firms must make when they consider the adoption of open platform procurement systems (such as Internet-based B2B e-markets) versus proprietary platform procurement systems, as well as some recently-emerged hybrids. We did so with a clear purpose in mind: to introduce a new risk-augmented transactions cost perspective that builds upon Malone, et al.’s (1987) electronic markets and hierarchies theory and Clemons, et al.’s (1993) move-to-the-middle theory. The types of systems that we have discussed generally match what we have seen in
industry during the last seven or eight years, with the move from EDI and other post-EDI proprietary solutions to the adoption of e-market and open platform solutions by new technology vendors. Our model characterizes the latter solution as involving the choice of a procurement system platform that brings along with it a trade-off between less costly but also more uncertain sources of supply, compared to more secure but costlier sources of supply. This emphasis on the importance of shocks is new to the literature, and provides a new theoretical lens though which to view and interpret what occurs in the marketplace, and how managers should make decisions about B2B procurement platform choices. The recent spate of news about the many failures in the B2B services marketplace points to the greater risks that are involved in the continuity of supply when a firm chooses to procure via the open platform procurement systems (Meehan, 2001), in spite of the larger number of suppliers. Our risk-augmented transactions cost perspective seems to be an appropriate expansion to existing thinking.

When firms take into account these procurement risks and uncertainties, our model instructs us to look for a specific pattern of behavior among them in the presence of the new technologies: larger firms are more likely to trade off demand and supply uncertainties with higher procurement costs and settle more often for proprietary systems. They will tend to adjust the related transactions costs for the uncontrollable risks that they face. Smaller firms, in contrast, will emphasize lower cost but less certain supply sources and opt for more open platforms and access to a larger number of suppliers. Thus, despite the attractiveness of the open platforms, both the open platform and proprietary platform procurement systems are likely to coexist, consistent with evidence developed elsewhere by Dai and Kauffman (2002a) and Belleflame (1988).

We are also able to characterize the circumstances for which an open platform for procurement may dominate existing proprietary platform EDI technology. Our insight, similar to that offered by Dai and Kauffman (2002a), is that the tendency towards standards-based platform solutions is generally beneficial. But there are also other countervailing considerations that will affect the actual choices that firms are observed to make. For example, there is a value-maximizing opportunity associated with selecting adaptable systems that can integrate with a buyer firms’ traditional EDI-based technology infrastructure. Such benefits form the basis for the attractiveness of some of the open platform solutions’ characteristics. Thus, we predict a convergence of both large and small firms to superior procurement technology that mixes open and proprietary elements. With this observation in mind, we offered a number of illustrative examples of these developments in the marketplace to support our modeling findings (like those offered now by Ariba and CommerceOne, in conjunction with their strategic alliances with other vendors).

Our main result is ironic: the increased supply chain management cost sensitivity of the smaller firms is a consequence of their higher exposure to over-supply risks. Smaller firms are forced to take even
greater risks to their lower procurement costs. We see these risks in practice with the business press news about the difficulties that firms face to make their procurement technology investments and their adoption of B2B e-market solutions pay off (Enos, 2001a and 2001b). In addition to supply shocks as a source of uncertainty, we also have included demand uncertainty in our model. Although we have not presented the results in the limited space available in this article, we have found that the model also works well to explain and predict technology adoption behavior in the aftermath of the historical decline of the DotComs. With the general economic slowdown in demand, we also have seen inventory build-ups that are similar to the unanticipated inventory build up that we model. One consequence is that the differences between the procurement systems adoption patterns of the larger and smaller firms will actually intensify.

Limitations

One limitation of our model is its lack of consideration of investment timing and vendor selection tactics when a hybrid of open and proprietary e-procurement solutions is selected. A second limitation is that we do not consider the possibility of vendor subsidies and the role of changing market psychology with respect to the upside benefits of B2B e-commerce procurement systems solutions. Vendor-side subsidies permit buyers and suppliers to adopt sponsored technologies, which develop network externalities and user benefits at a different rate and for different reasons than what a technology purist might argue is a “first-best” technological solution in a given setting. Thus, we view modeling sponsorship and subsidies as some next steps with this research, as Riggins, et al. (1994) recognized was important in the context of EDI. Finally, even though our model considers the downturn in economic growth that affected the DotComs, we do not treat the market’s rational expectations about specific vendors (some of which, like Ariba and CommerceOne, are among the DotComs whose equity prices and viability have been hard hit). Clearly, vendor reputation and future expectations of the market matter, especially among new market entrants, where adopter expectations about future success are key.

A third limitation of our model and results is that they are developed and stated within the context of a firm-size proxy for inventory policy, the order quantity. We do not permit the possibility of a secondary market mechanism to dispose of or trade away excess information, as in Lee and Whang (2002). Nor do we directly include the details of optimal inventory policymaking, and how it ties in with technology platform selection. The optimization of periodic inventory replenishment policy is likely to vary for the buyer by supplier, by product type and based on expectations of figure period demand and supply forecasts, in lieu of information from just one period. Firms that are able to recalibrate inventory reorder points flexibly, as they obtain new information, are likely to want to hold out larger portions of their average purchase levels for spot-buying, which will tend to favor the selection of e-market-based procurement solutions, and contracts with suppliers who are willing to share the gains associated with more informed purchasing approaches. If a buyer’s supply chain partners are willing to provide this kind
of “slack” and operational flexibility, and split the gains that might be shared by all firms, they will reduce the buyer’s perception of risk and appreciate the nature of its self-interest. This will diminish the buyer’s emphasis on the procurement system-side cost considerations. We hope to treat these issues more fully in future research.

In conclusion, we remind the reader of the following practical perspective that matches the arguments that we have been making in this article:

*What is required is a realistic and sustainable structure for e-business platforms that: (1) drives adoption toward critical mass; (2) reduces risk for all [ ] players; (3) leverages the self-interest of the individual firms; and (4) remains truly pro-competitive in structure, not just through artificial safeguards*” (SureFoods, 2001).

Clearly, there is still much to be learned before we can provide definitive guidance for senior managers about how to get these aspects of their procurement systems right. But recognizing the important role of shocks and demand and supply uncertainties’ effects on procurement costs and procurement system platform choice is a step in the right direction.

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Appendix. Examples from the Industry Press to Illustrate Some Modeling Propositions

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<th>PROPOSITION</th>
<th>ILLUSTRATIVE EXAMPLES AND SOURCE</th>
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<td><strong>PROPOSITION 1 (ADOPTING FIRM'S SUPPLY SHOCK ABSORPTION CAPACITY PROPOSITION).</strong> Buyers with greater market power are better able to absorb the adverse effect of oversupply shocks, by reducing prices, than those with little or no market power. They also are more adversely affected by supply and demand uncertainties than are competitive buyer firms.</td>
<td>Dell Computer, a major vendor of personal computers and server technologies, enjoys considerable market power in the markets it serves, in spite of the high level of competition that its competition among one another. Dell’s capabilities to reduce prices and move products based on non-current generation chip sets and other internal hardware are legendary. However, one of the firm’s greatest vulnerabilities in the market is its inability to satisfy the pent-up demand of consumers in the market in the presence of supply problems for computer components that hold up shipments. Personal computer manufacturers, such as Dell and Gateway, recognize that the costs associated with stockouts go far beyond individual customers who are affected. Instead, they have ripple effects that are transmitted market-wide.</td>
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<td><strong>PROPOSITION 2 (PROCUREMENT RISK-TO-COST CONVEXITY PROPOSITION):</strong> A buyer’s iso-profit curve associated with procurement system platform adoption in the parameter space of supply procurement risks versus costs is convex.</td>
<td>Optiant Inc., a supply chain management software solutions provider, had a press release in early 2002 that illustrates this proposition. “Contrary to widely-held rules of thumb, increasing buffer inventory amounts is not the answer to increasing customer service levels. In fact, keeping extra inventory around to buffer shocks like those caused by September 11 is very costly and doesn’t necessarily guarantee improved service to customers. For the U.S. economy a 5 percent increase in inventory levels would represent an extra working capital of $75 billion. In terms of associated expenses, carrying this additional inventory will cost businesses across the U.S. a total of about $18 billion.” The firm also recommends that senior managers in supply chain management “[b]alance supply and demand while counterbalancing risk. Planning supply chain strategies around demand uncertainty (including forecast error, unexpected spikes/dips in demand) and supply unpredictability (including limited capacity, supplier delays, and critical parts shortages) equips corporations with agile supply chains that can handle uncertainty.” Optiant Inc., “Manufacturers Will Make 2002 the Year for Optimizing Supply Chain Performance,” Press release, Optiant Inc., Somerville, MA, January 8, 2002. Available at <a href="http://www.optiant.com/news_pressrel_resolutions.htm">www.optiant.com/news_pressrel_resolutions.htm</a>, accessed September 20, 2003.</td>
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<td><strong>PROPOSITION 3 (ADOPTING FIRM'S SELF-SELECTION PROPOSITION).</strong> Buyers rationally self-select into different groups. Smaller buyers firms adopt procurement systems platforms that entail lower costs but higher supply variance (i.e., open platforms). Larger buyer firms adopt procurement systems platforms that entail higher procurement costs but lower supply variance (e.g., the more traditional proprietary platforms).</td>
<td>Celestica Inc., a large Toronto, Canada-based electronics supplier illustrates the importance of adopter technology self-selection. “Celestica promotes collaboration and teamwork to improve flexibility, reduce costs, and maintain our lead in technology and innovation at the manufacturing level. We work with customers to build tighter relationships through on-site planners. We work with suppliers to enhance our supplier-managed inventory programs. We work within Celestica to maximize the advantages of our open architecture to enhance application interfaces. … Yet how can a unified supply chain access current product demand information? And how does a unified supply chain align suppliers, OEMs and the EMS [electronic manufacturing services] provider to sudden inventory changes? A dynamic replenishment strategy involves on-site planning at OEMs’ facilities to successfully execute a global, unified supply chain operation, as well as anticipate supply changes. … Advanced Planning Systems software, as offered by leading software companies, delivers to the EMS provider an additional tool to forecast sudden changes in supply and order rates, as well as access to historical patterns of demand. This decision support simulation application draw information from ERP systems to estimate line-capacity thresholds, supply shortages, order increase and their impact on delivery dates .. Suppliers and OEMs can pull this information along the unified supply chain, making each link more responsive and flexible to market fluctuations. … As Web-based EDI and integrated advanced planning become more common, the unified supply chain will provide to be an even greater strategic business tool that not only delivers bottom line, quick-to-market results, but competitive advantage. “Building a Global Unified Supply Chain,” White Paper, Celestica, Inc., Toronto, Canada, Available at <a href="http://www.celestica.com/cfm/pdf/SCMWP-pageview.pdf">www.celestica.com/cfm/pdf/SCMWP-pageview.pdf</a>, accessed September 15, 2003.</td>
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<td>PROPOSITION</td>
<td>ILLUSTRATIVE EXAMPLES AND SOURCE</td>
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<td><strong>PROPOSITION 4 (HYBRID PLATFORM PROCUREMENT SYSTEM ADOPTION PROPOSITION).</strong> The emergence of a more adaptable hybrid platform that reduces both procurement costs and supply uncertainty will attract both large and small buyers, and will dominate both the proprietary and the open platforms.</td>
<td>Ariba Buyer is a hybrid technology solution in that it provides connectivity with legacy systems that support procurement, with current open systems technology associated with the World Wide Web. The following quotation involving Dell Inc. illustrates the attractiveness of a hybrid technology platform solution in terms of its capabilities to lower procurement costs. “Trading inventory for information is a key to Dell’s supply chain success, and in this day of point solutions aimed at tackling small problems quickly, Dell again is proof that following its own course is the way to go. Dell runs what is said to be the world’s largest implementation of i2 Technologies Inc.’s software, running its Dell-specific DSi2 solution on 120 servers, managing more than 250 suppliers responsible for delivering over 3,500 components. … Dell implemented Ariba Buyer over a seven-month period, interfacing the procurement solution with nearly 20 of Dell’s legacy systems, including links to Oracle Financial for purchase order, cost center and accounting code data. The result—called Dell Internet Requisition Tool—provides automated processing of fully validated orders. The system reduced the time to complete a requisition by 62% and the cost by 61%, in addition to reducing the number of errors.” D. G. Jacobs, “Anatomy of a Supply Chain,” Total Supply Chain Technology News, March 2003, 20-22. Available at <a href="http://www.totalsupplychain.com">www.totalsupplychain.com</a>. See <a href="http://www.ariba.com">www.ariba.com</a> and “Ariba Procurement Solution Overview,” <a href="http://www.ariba.com/solutions/procurementoverview.cfm">www.ariba.com/solutions/procurementoverview.cfm</a>. Accessed October 4, 2003.</td>
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<td><strong>PROPOSITION 5 (DEMAND VARIANCE PROPOSITION):</strong> As the buyer’s profits fall with higher demand uncertainty, the trade-off between costs and supply variance shifts in favor of giving greater weight to the role of supply variance (indicated by the nature of the “tilt” in the shifting of the iso-profit curve).</td>
<td>Retail firms that have highly seasonal fashion and customer products (e.g., textiles, apparel and clothing) tend to be more subject to the adverse effects of oversupply stocks. They include apparel manufacturers Kimberly Clark, Haggar Clothing Co., Sara Lee Knit Products, Fieldcrest Cannon, and retail stores JC Penney, Lands End, L.L. Bean and Target Stores. These firms have sponsored research on the effects of retail demand uncertainty related to the performance of their supply chains. They note the relatively high importance of agile, reactive and custom manufacturing, flexibility and short lead time, modular design and product differentiation, and small lot sizes. Firms in the same industries that produce and sell more basic apparel (non-fashion) tend to emphasize large lot size, and maximum quality for minimum cost, along with minimum inventory costs. See andia Laboratories, “Demand Activated Manufacturing Architecture Project” (DAMA), <a href="http://www.dama.tc2.com">www.dama.tc2.com</a>, accessed on October 5, 2003.</td>
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