OPEN VERSUS PROPRIETARY SYSTEMS IN B2B E-PROCUREMENT:  
A RISK-ADJUSTED TRANSACTIONS COST PERSPECTIVE

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ABSTRACT

This article presents an economic model that enables the study of incentives for business-to-business (B2B) e-procurement technology 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, and conclude that it is appropriate to rethink prior theory in lieu of a more explicit risk-adjusted transactions cost theory perspective, following Clemons, Reddi and Row (1993). We distinguish among three kinds of B2B e-procurement technology platforms that can be selected: traditional interorganizational systems (IOSs), open B2B platforms associated with electronic markets on the Internet, and hybrid solutions that involve elements of both. The key dependency appears to be firm size. 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 B2B procurement platforms. We arrive at our findings through the specification of an analytical model that captures the key elements of our perspective—transaction costs, agency costs and information uncertainty—and attempts to specify the limits of the conditions under which one can make strong conclusions about the likely observed equilibrium e-procurement solutions of firms.


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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 (Mahoney, 2001; SPS Commerce, 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 website” (BusinessWire, 2001). Indeed, many observers view the new technologies in this area 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).

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. Among the most attractive features of B2B procurement transactions on the Internet is the fact that buyers do not need to make costly long-term commitments to dedicated and hard-wired procurement systems associated with electronic data interchange (EDI). (See Table 1.) Yet the available evidence points to the persistence of such proprietary systems despite the higher costs of procurement (Dai and Kauffman, 2002a).

1 The market was projected to reach $2.2 trillion by 2003, and $7.4 and $8.5 trillion in 2004 and 2005, respectively.
Table 1. Firm Benefits in B2B E-Procurement

<table>
<thead>
<tr>
<th>SUPPLIER BENEFITS</th>
<th>BUYER BENEFITS</th>
</tr>
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<tbody>
<tr>
<td>Small order aggregation</td>
<td>Lower cost method to find and select suppliers</td>
</tr>
<tr>
<td>Lower customer acquisition costs</td>
<td>Improved negotiation due to larger orders and transparency</td>
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<td>Lower transaction costs</td>
<td>Lower transaction costs</td>
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<tr>
<td>Reduced time to market</td>
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Source: Adapted from Transora (www.transora.com).

To explain why this may be occurring, researchers have pointed out the importance of the role of buyer-supplier coordination as a desirable property for downstream firms (Barua, Kriebel and Mukhopadhyay (1995)). However, there has been significant debate as to the nature of the interplay among the players (e.g., Clemons, Reddi and Row, 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 uncertainties that are associated with this new generation of Internet-based systems support. We will argue in this paper, extending the “move-to-the-middle” theory of Clemons, Reddi and Row (1993), that firms make these kinds of considerations in a manner that is consistent with a new “risk-adjusted transactions cost theory” perspective.

We can see the beginnings of such a perspective by considering the frequency of procurement purchases and the extent to which the parties involved are able to transact on a regular basis. We believe that an important aspect of the value that a buyer might place upon Internet-based procurement can be tied to the extent to which procurement activities occur on a regular or irregular basis, involving the same or different trade partners, for supply items whose prices are relatively stable or tend to float in a wide enough band so as to create financial risk in procurement. In addition, 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 engage just a few or many suppliers.

Dai and Kauffman (2002a) discuss some of these tradeoffs and conclude that the success of a open B2B procurement 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 interorganizational systems (IOS) technologies 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 (www.ariba.com), Commerce One (www.commerceone.com) and i2 (www.i2.com), and their adaptability to existing EDI technologies. A recent Jupiter Research report 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). Meanwhile, the aforementioned firms have had their own difficulties to convince the marketplace that their solutions can offer sustainable cost advantages to the adopters.

Transaction Costs, Risk, and Market Demand / Supply Uncertainties

In this article, we will develop an economic model that shows how the nature of the tradeoffs discussed above are likely to lead to the co-existence, in equilibrium, of both open B2B systems and proprietary IOS systems that support procurement. The key dependency, as we will shortly show, is firm size. This dependency only arises in the context of differential transaction costs, IOS and e-market participants who have different sensitivities to risk, and uncertainties about market demand or supply. The emergence of co-existing networks in our examination is paralleled by the findings of Belleflamme (1998), whose work examined network technology adoption under oligopolistic competition market structures. In contrast to the results that we will report for B2B e-commerce technology platform adoption, which emerge from the tradeoff between procurement transaction costs and supply uncertainties, Belleflamme’s results depend on the degree of product substitutability that is observed in the market.

Our model focuses on uncertainty in the B2B procurement context, for both the demand side and the supply side of procurement. We will study how the choice of information technology (IT) may reduce procurement uncertainties and, in turn, how aggregate demand side uncertainties may influence the firm’s choice of IT procurement systems. A key emphasis is on the role of unanticipated inventories associated with these uncertainties. Thus, our model is well equipped to interpret the influence of the economic slowdown, and the nearly unprecedented inventory build-up that has accompanied it, on firm choices of supply chain technologies.

There are observers in the business press who suggest that the DotCom “meltdown” since summer 2000 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 a proprietary supply chain management solution suggests. (See Text Box.)
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 $700 million, but it was able to hold the line on excess inventory, which increased by only $300 million. This favorable outcome was achieved at a cost of some CAN$60 million of investment 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 a risk-adjusted transactions costs perspective and why it is helpful to understand the kind of technology-based interorganizational e-procurement solution that the firm was willing to invest in. 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.

But, despite the positive impression that is created by Celestica Inc’s story, there are still numerous managerial issues and challenges. Chief among them is the issue of the business value that accrues to IT investments in the supply chain area, and how the value is split among participants, so that they can optimize their participation and investments. For example, Hwang, Pegels, Rao and Sethi (1993) identified initiators and followers in the EDI systems adoption context, to distinguish between firms that adopted for their own benefit and other firms that were forced to adopt to achieve compliance with a strong buyer. Economic analysis has been widely applied in IS research to understand the ways that IT creates value (e.g., Barua, Kriebel and Mukhopadhyay, 1995; Brynjolfsson and Yang, 1996; and Dos Santos and Peffers, 1995). It has also been applied 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., Mukhopadhyay, Kekre and Kalathur, 1995; Mukhopadhyay, Kekre and Pokorney, 1998; Riggins, Kriebel and
and Mukhopadhyay, 1994; and Riggins and Mukhopadhyay, 1999), the University of Rochester (e.g., Wang and Seidmann, 1995), and the recent work on B2B electronic market technology investment and adoption from the Universities of Calgary and British Columbia (e.g., Bakos and Nault, 1997; Nault and Dexter, 2000) and the University of Minnesota (e.g., Dai and Kauffman, 2000, 2002a, 2002b), there are still relatively few analytical and empirical economics models in this area. Moreover, few address the issue of technology adoption in B2B electronic markets and supply chain management with a perspective on current technological choices, and the role of the value of the information that becomes available to management to deal with market uncertainties. The present paper is a new effort in this direction, and should be of interest in terms of approach it uses to advance theory in this area.

The remainder of the paper is organized as follows. The following section provides the background literature and referent theory that establishes our own unique theoretical perspective. The third section presents the basic formulation of a risk-adjusted transaction cost evaluation model that permits us to bring transaction costs, demand and supply uncertainty, and procurement risk into focus. The fourth section introduces additional background on the technology support context that is present in electronic procurement, and discusses the difference between proprietary and open platform e-procurement technology solutions. This permits us to more formally analyze the model to develop the results of this research. The fifth section extends the fourth by considering how adoption outcomes change when there is the possibility that a prior adopter of one technology solution can switch to another type, as well as what happens when it is possible to have adoption of hybrid solutions. Another brief sections consider another question that our model can treat: how does economic downturn affect the results that we have obtained, and what is the likely impact on the trends that we should expect to see with B2B e-procurement solution technology adoption? Just prior to the conclusion, we consider the managerial relevance of our five propositions. Then the final section assesses the contributions and limitations of this work, and our thoughts about future extensions and further developments in this line of research.

BACKGROUND THEORY AND LITERATURE

We next consider the theoretical backdrop for the perspectives on e-procurement technology solution adoption that we present in this paper. The key findings from the referent literature are developed in the context of transactions cost theory, electronic markets and hierarchy theory, and the more recent theory associated with the property rights of the firm and incomplete contracts.

The Dynamics of Buyer-Supplier Relationships

Information technology has been recognized as having the capability to transform the way that markets work, and the way that firms interact with markets and among themselves. However the nature of this transformation has been subject to somewhat different interpretations. The key issues that the
leading authors have considered is the extent to which greater outsourcing is likely to occur, and the extent to which buyers tend to deal with a focal set of suppliers or a broader set of suppliers that represent more of the market at large. In the development of a new electronic markets and hierarchy hypothesis, Malone, Yates and Benjamin (1987, 1989) offered new theory about the predicted changes in the structure of market exchange in the presence of electronic communication technologies. They predicted that the impacts of IT would be to induce firms to increasingly transact in electronic market settings. Somewhat later, Clemons, Reddi and Row (1993) proposed a move-to-the-middle hypothesis. The essence of their view was that, as IT increases the information available to a firm and its capabilities to meaningfully process this information, coordination costs, and operational and opportunism risks would all fall. They cogently predicted the move to a focal set of suppliers, in spite of the new electronic communication technologies, matching what we actually see in industry today, to a great extent.

The number of suppliers that are likely to be observed to participate in interorganizational procurement networks has been an important theme in IS research. For example, Riggins, Kriebel and Mukhopadhyay (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 that would force suppliers to offer lower prices.

Nevertheless, as the number of suppliers participating in an interorganizational system 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 interorganizational systems assets for procurement purposes, with the result that more outsourcing will occur. Thus, a leading prediction associated with this literature is that the presence of reduced transaction costs will lead to more interorganizational coordination (Han, Kauffman and Nault, 2003).

Related to this is the development of increased information sharing, both in strategic and in operational terms, to ensure that the firms’ business processes are taking appropriate advantage of one another. However, one expects to observe some friction in the process. Systems integration is an important consideration in 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) point out. Another 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, another 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.). 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, on that basis, determine ownerships and investment levels. Overall, as Clemons, Reddi and Row (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 has 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 undue risks in the arrangements that it makes for e-procurement.

To illustrate, at one end of the spectrum, consider a firm that may face 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. Such a perspective may then impact firm’s willingness to engage in market-based e-procurement arrangements, if such arrangements would expose the firm to an unacceptable level of uncertainty regarding supplier performance. To the extent that e-procurement arrangements move firms to the lowest cost supplier, risks in delivery and quality are especially magnified.

At the other end of the spectrum, a firm that faces highly unstable demand 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 costs 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-adjusted transaction cost” perspective in the choices that they make about the procurement solution technologies and buyer-supplier arrangements that they make. Firms will indeed take into account the potential effects of IOS investments in maximizing the value of their procurement activities, but the exact nature of the solution that is adopted will have a more complex interdependence on other factors beyond those that transaction costs theory, electronic markets and hierarchies theory, and even the “move to the middle” hypothesis suggest.

The Roles of Firm Size and Economic Forces

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, Dow and Grover, 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 B2B e-procurement 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 tend to have a competitive advantage with respect to larger and more complex software projects, increasing their willingness to choose solutions for which they must bear significant uncertainty in future costs. Cohen and Levinthal (1990) point to the importance of the absorptive capacity of the firm with respect technological innovations. Their work and the work of other that point to the importance of organizational knowledge and technology-related competencies (Winter, 1987) have sensitized IS researchers to recognize the importance of such capabilities especially when there is rapidly-moving technological progress occurring, as we have recently seen with electronic commerce.

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, McAndrews and Wang, 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, Benbasat and Dexter, 1995). Their smaller size may predispose them to select from among solutions that allow them to tap into more immediate network externality benefits (Au and Kauffman, 2003) or require fewer costs for customization (Gebauer and Segev, 2002).

It is also long-recognized that firm IT investment behaviors track the business cycle forces of the economy (Roach, 1987 and 1988). The difficulty that firms face with technology adoption in the presence of economic growth and decline is primarily a problem of finding the resources and setting organizational expectations about investment returns at an appropriate level in the presence of uncertainty. Because of the resources that large firms control, they are better able to invest while “looking beyond” the current economic conditions to the potential for future growth of revenues and earnings. Small firms have far less of an ability to sustain IT projects in the face of an economic downturn; their resources are typically too limited. Thus, business cycles may drive a further wedge between the behavior of large firms and small firms with respect to IT adoption decisions.

AN ADOPTION DECISION MODEL FOR E-PROCUREMENT TECHNOLOGY

Early efforts to support B2B 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 sophisticated optimization algorithms (Kumar, 2001). During the last decade, increases in computing power have enabled the use of these algorithms in complex supply chain situations, and permit firms to manage uncertainties that arise in the process as never before. These capabilities are now being extended to the technological solutions for B2B e-commerce. Our focus is on the economics of uncertainty in the supply chain process, so we turn to the development of a model that incorporates this consideration and enables us to understand B2B technology 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 retailer procures its supplies in a competitive market subject to supply uncertainties from the upstream supplier.

The retail electronics sector, a long-term and significant sectoral user of EDI, is a good case in point. For example, despite some 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. These stock-outs stem both from supply uncertainties as well as demand forecasting uncertainties. 

In contexts such as we have just considered, four aspects of the retail firm stand out relative to supply chain management. These include:

- 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.

**Stochastic Demand and Supply Uncertainty.** Demand uncertainties arise from that fact that final sales are subject to stochastic shocks that the firm’s management cannot predict, that is:

\[ q_{d} - q_{s} = \delta q_{s} \Rightarrow q'_{d} = (1 - \delta)q_{s} \]  

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), \( q_{s} \) 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. To keep the analysis realistic, this error is assumed to be relative and, thus, we model it proportional to the magnitude of the supply (hence \( \delta q_{s} \) 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 truncated normal) in the interval \([-1,1]\).

Uncertainty 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. Thus, we write:

\[ q_{s} - q_{o} = q_{o} u \Rightarrow q_{s} = (1 + u)q_{o} \]  

with \( u \sim g(0, \sigma_{u}^2) \) and \( u \in [-1,1] \). In this relation, the distribution \( g \) can also be any symmetric truncated distribution. The source of fluctuations in the supply channel is likely to be independent of any random fluctuations in demand so that \( \text{cov}(\delta, u) = 0 \). Then, the variable \( q_{o} \) is the control variable that management wishes to optimize (similar to what we described in the Celestica example).

**Calculating Retailer Profits.** The retailer’s expected profits \( E(\pi_r) \) may now be calculated by

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2 Since most of Best Buy’s products are procured on a national basis, Best Buy faces much greater competition in procurement against the other regional leaders than it does in its product market. For example, Best Buy leads in central states while Circuit City leads in the western states.
integrating its objective function over the two uncertainty dimensions:

\[
E(\pi_s) = \int_{-1}^{1} g(u) du \int_{-1}^{1} \pi_s(q_s, q_d') f(\delta) d\delta
\]  (3)

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

\[
E(\pi_s(q_s)) = P(q_s)q_s \cdot \text{prob}(q_s < q_d') + P(q_d)q_s \cdot \text{prob}(q_s < q_d') - c[q_s \cdot \text{prob}(q_s < q_d')] + q_s \cdot \text{prob}(q_s > q_d')] - s(q_s - q_d') \cdot \text{prob}(q_s > q_d')
\]  (4)

where, \(P(\cdot)\) 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, with the idea in mind that storage costs are cumulative over time. (For example, in the food retail 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 can express the probabilities in Equation 4 in terms of \(\delta\) and its density function \(f(\delta)\) from Equation 1. We note that \(0 \leq \delta \leq 1\) when \(q_s \geq q_d'\) and \(0 \geq \delta \geq 1\) when \(q_s \leq q_d'\). The conditional expected profit in Equation 4 is:

\[
E(\pi_s(q_s)) = \int_{0}^{1} P(q_s)q_s f(\delta) d\delta + \int_{0}^{1} P[(q_s (1 - \delta)] \cdot q_s (1 - \delta) f(\delta) d\delta - cq_s \int_{0}^{1} \delta q_s f(\delta) d\delta
\]  (5)

This can be simplified because \(q_s\) is a 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:

\[
E(\pi_s(q_s)) = (1/2)P(q_s)q_s + \int_{0}^{1} P[(q_s (1 - \delta)] \cdot q_s (1 - \delta) f(\delta) d\delta - cq_s - sq_s \Omega_{\delta}
\]  (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 $u$:

$$E(\pi_r) = \int_{-1}^{1} E(\pi_r(q_s))g(u)du$$  \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 $u$, as arguments of the inverse demand function of $P[q_o(1+u)]$ and $P[q_o(1+u)/(1-\delta)]$. 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:

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

where the final term is given by

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

Notice in Equations 8a and 8b that although the supply and demand uncertainties, $\sigma^2_\delta$ and $\sigma^2_o$, 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., $q_s > q_o f$, 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 $\sigma^2_o$, exists only when firms enjoy some market power, but disappears otherwise. This leads us to assert the following proposition:

**The Adopting Firm’s Supply Shock Absorption Capacity Proposition (P1).** Retail firms 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 firms.

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 and the analysis is tractable. Specifically, we let \( P(q_o) = a - bq_o \). The first order condition for optimization yields:

\[
\frac{dE(\pi_o)}{dq_o} = 0 \Rightarrow q_o^* = \frac{1}{2b} \cdot \frac{(a-c)-(a+s)\Omega_s}{(1+\sigma_u^2)(1+\frac{1}{2}\sigma_u^2-2\Omega_s)}
\]

(9a)

\[
\pi_o^* = \frac{1}{4b} \cdot \frac{[(a-c)-(a+s)\Omega_s]^2}{(1+\sigma_u^2)(1+\frac{1}{2}\sigma_u^2-2\Omega_s)}
\]

(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, \( a(1-\Omega_s) > c + s\Omega_s > 0 \). 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, \( \sigma_s \) and \( \sigma_u \), adversely affect optimum output and profits. However, the parameter \( \Omega_s \) 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 B2B 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) in the mix. We will later consider hybrid platforms. Understanding the issues that they present and the responses they elicit from the firms with respect to platform adoption decisions will serve as a basis for developing additional insights on the role of transaction costs and risk perceptions in procurement.

Proprietary Versus Open Platform Adoption

To probe this further, we next extend our model by considering two forms of electronic procurement technology solution, \( \phi_1 \) and \( \phi_2 \). Each is characterized by different levels of procurement costs and supply risks. They are as follows:

- **Proprietary platform technologies (OIS/EDI):** Technology \( \phi_1 \) exposes the adopter to relatively high procurement transaction costs \( c \), but the procurement risks given by \( \sigma_u^2 \) are low because
many relatively reliable long-standing suppliers will be the focus of the interorganizational network.

- **Open platform technologies.** Technology $\varphi_2$ causes the adopter to face relatively low procurement transaction costs, $c$, but there are high procurement risks, as depicted by the cost variance $\sigma_u^2$ because relatively fewer suppliers will have been able to achieve open platform connectivity (at least short-run, when value flow considerations are made by the adopter).

Our characterization of proprietary version open systems is meant to emphasize special contrasts. The variable $\varphi_1$ represents proprietary procurement systems. These include traditional and Web-based 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 B2B technology platforms that are associated with Internet-based supply chain management systems (e.g., Ariba, i2 and CommerceOne, prior to their moves to incorporate other firms’ proprietary software capabilities to build their suites of supply chain software capabilities).

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 surfaces, $\pi^e_r$, and totally differentiating Equation 9b with respect to $c$ and $\sigma_u^2$, yielding:

$$ \frac{d\sigma_u^2}{dc}|_{\pi^e_r} = \frac{1}{2b} \frac{1}{\pi^e_r} \left[ \frac{(a-c)-(a+s)\Omega_d}{1+\frac{1}{2}\sigma_u^2-2\Omega_d} \right] $$

(10a)

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

$$ \frac{d\sigma_u^2}{dc}|_{\pi^e_r} < 0 $$

(10b)

This negative slope describes a trade-off between a firm's choice of technologies 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 surface, we can find the sign of curvature of the trade-off curve. Differentiating Equation 10a with respect to $c$ to

---

$^3$ 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**.
obtain:
\[
\frac{d^2(\sigma^2_u)}{dc^2} = \frac{1}{2b} \cdot \frac{1}{\bar{\pi}_r} \cdot \frac{1}{1 + \frac{1}{2}\sigma^2 - 2\Omega^2} > 0 \quad (11)
\]

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.

**Figure 1. The Retailer’s (Buyer’s) Technology Adoption Iso-Profit Curve**

This leads us to assert a second proposition:

**The Procurement Risk-to-Cost Convexity Proposition (P2):** *A firm’s iso-profit curve associated with B2B technology platform adoption in the parameter space of supply procurement risks versus costs is convex.*

**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 open versus proprietary B2B technology platforms 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:

\[
g_o^* = \frac{2\pi_e^*}{(a-c)-(a+s)\Omega^2} \quad (12)
\]

Next, suppose that profits are held at their maximum level. Sales will still vary depending on the quantity in the denominator and especially, unit procurement cost, \(c\). Among all firms that earn *same* profits (specified by \(\pi^*_e\) in Equation 12), and lie on the iso-profit contour shown in Figure 1, firms with *higher* unit procurement costs will tend to be the *larger* ones (based on \(g_o^*\) in Equation 12), lying on the lower part of iso-profit contour. By the same token, firms with the *lower* procurement costs will tend to be the *smaller* ones, and will lie on the upper part of iso-profit contour. (See Figure 2.)
From this result, the following the following proposition emerges:

**The Adopting Firm’s Self-Selection Proposition (P3).** Firms rationally self-select into different groups. Smaller firms adopt technologies that entail lower costs but higher supply variance (i.e., open B2B technologies). Larger firms adopt technologies that entail higher procurement costs but lower supply variance (e.g., the more traditional IOSs and the new proprietary solutions).

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 IOS technologies 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 the case of 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 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 risks with respect to systems success that a small firm might face are going to be amplified. 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, they still are more susceptible to outright project failures.
failures are more likely to be due to the complexity and variety of suppliers. In addition, larger organizations operate with an exponentially complex network of buyers and suppliers, 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 strategy 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” electronic commerce services 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 spite of the fact that they have to bear higher transaction costs.

In contrast, smaller firms are willing to sacrifice supply process risks for lower procurement costs they obtain by adopting open B2B e-commerce platforms. There 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. (www.vailresorts.com), 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.

ANALYZING B2B TECHNOLOGY 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. The last few years, 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 is known to produce measurable business value due to improvements in operational aspects of procurement (e.g., Kekre and Mukhopadhyay, 1992; Mukhopadhyay, 1993; Mukhopadhyay, Kekre and Kalathur, 1995).

But will new B2B platforms be perceived as having potential to create enough value so traditional
users of EDI technologies in supply chains make the switch? To provide insights, we model a third kind of B2B platform. A hybrid adaptable B2B technology platform is defined as a more adaptable technology platform, \( \varphi_3 \), which gives the adopter to low 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 we discussed.

Hybrid B2B technology 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 may be 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. 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. In doing so, IBM is able to adapt to the client’s traditional proprietary systems, an example of hybrid adaptable technology.

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

**Figure 3. Adaptability Impact of a Hybrid Technology Platform**

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 line, i.e., an IT investment frontier that corresponds to a higher profit level for the hybrid B2B technology 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 follows:

**The Hybrid Technology Solution Adoption Proposition (P4).** The emergence of a more adaptable or hybrid technology that reduces both procurement costs and supply uncertainty will
Although a hybrid technology solution offers “win-win” possibilities in terms of reduced procurement costs and reduced supply variance, a firm with large installed and large investments in 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 a transformation of the IT systems 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 would overcome this inertia and switching occurs.

Following up on the structure of our prior model, consider two states of the world. In State 1 the firm owns a legacy technology such as $\phi_1$ or $\phi_2$, but is considering moving to State 2, characterized by a new technology $\phi_3$ 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 technology, 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:

$$ (\pi^e_1)_{STATE_1} = A[c_{STATE_1},(\sigma_u^2)_{STATE_1}] $$ (13a)

$$ (\pi^e_2)_{STATE_2} = A[c_{STATE_2},(\sigma_u^2)_{STATE_2}] - r(F_{NEW} + F_{OLD}) $$ (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. 4

Given the above discussion the switch over to the new technology occurs if $(\pi^e_2)_{STATE_2}$ is a least as large as $(\pi^e_1)_{STATE_1}$, 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 technology 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 technology be large enough to induce the firm to switch? Clearly, the larger are the costs associated with the new technology, the more difficult it will be. One likely factor influencing the size of

---

4 State 1 does not entail any fixed costs. We assume the technology has been in place for some time 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.
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 technology compared to the State 2 technology. These issues suggest that traditional proprietary systems such as EDI are likely to entail greater transition costs:

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

Thus, adoption from these legacy systems to the hybrid technology will encounter larger inertia. Figure 4 shows this result. (See Figure 4.) The figure shows that firms that have already adopted the proprietary technology, \( \varphi_1 \) (e.g., IOS or 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 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 B2B technology platform, will adopt either \( \varphi_3^{INFERIOR} \) or \( \varphi_3^{SUPERIOR} \).

**Figure 4. Technology Adoption Inertia**

\[
(\pi_{r}^{\text{*}})_{STATE_1} = A[c_{STATE_1}, (\sigma_u^2)_{STATE_1}]
\]

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

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

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

**THE IMPACT OF AN ECONOMIC DOWNTURN**

The recent economic downturn and the collapse of the DotCom and technology sectors that has accompanied it have triggered a massive unanticipated inventory accumulation across a number of industrial sectors. Many firms were unprepared for this change, and thus they experienced an increase in the value of the parameter \( \Omega_\delta \), unexpected over-supply, in our model. In this context, we can ask another related question that our model for which our model can offer useful insights. What is the likely effect of
this downturn on the existing and future distribution of technology platforms among firms? Are the changes likely to impact the viability of the proprietary or open technology platform providers?

Since firm size has been shown to be an important factor in the pattern of firms’ technology adoption in our model, we must first ask: How will an economic slowdown is likely to affect firm size? Consider the effect of $\Omega_\delta$ on firm size and profitability for two firms of different sizes. Suppose that both firms face demands with same slope, $b$, but $a_l > a_s$, with $a_l$ and $a_s$ representing the vertical intercept of inverse demand for large and small firm market shares (subscripted $l$ and $s$, respectively). First, from Equation 9b we can observe the ratio of the profits of the two firms:

$$\frac{\pi^e_r(a_l)}{\pi^e_r(a_s)} = \left[\frac{(a_l - c) - (a_s + s)\Omega_\delta}{(a_s - c) - (a_s + s)\Omega_\delta}\right]^2$$

(16)

It is now possible to see what happens to the profits of the two types of firms in the face of an unexpected over-forecast of demand, leading to a rise in $\Omega_\delta$. To see this, we differentiate the profit ratio shown in Equation 13. This yields the following informative result:

$$\text{sign}\left[\frac{\partial}{\partial \Omega_\delta} \frac{\pi^e_r(a_l)}{\pi^e_r(a_s)}\right] = \text{sign}(a_l - a_s)(c + s) > 0$$

(17)

Equation 17 tells us that an unanticipated inventory build-up creates a gap between small and large firms in terms of relative profits, favoring the larger ones. This leads us to:

**The Unanticipated Inventory Build-Up Effects Proposition (P5):** An unanticipated inventory buildup favors large firms over smaller firms. The greater are the unit production and unit inventory costs each experiences, the larger will be the profit gap between the two.

Combining this result with what we learn about B2B technology platform choices of firms, it is evident that smaller firms that are forced to contract further after the economic slowdown will be more likely to adopt procurement technologies with lower costs—even at the cost of higher procurement risk. In contrast, firms that experience either no contraction or further expansion are more likely to adopt technologies with higher costs but lower supply variance.

**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 in terms of capacity to set prices. This almost immediately suggests the structure of the market in which the adoption decisionmaking 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 that is
taken, 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 effect of greater uncertainties with respect to both demand and supply tends to 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 “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. It is along this procurement risk-procurement cost iso-profit curve that the differences in the impacts of the technology adoption choices materialize. Our third proposition, the “Adopting Firm’s Self-Selection Proposition,” suggests the fundamentally different perspectives of large and small firms. Since small firms face critical constraints on their spending for infrastructure development, they should seek to 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 an open B2B 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 to find solutions that reduces both procurement costs and the uncertainty of supplies. In recent years, we are actually seeing such opportunities come to the marketplace, as the emerging technical solutions that are based on open source technologies are increasingly being integrated to reduce adopter costs while still providing a basis for achieving greater connectivity between buyers and suppliers.

Our fourth proposition, the “Hybrid Technology Solution Adoption Proposition” posits that such emerging solutions will attract both large small firms, in spite of their consideration of risk-adjusted transactions costs. 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, CFRP, or open standards e-market platform connectivity) 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 both 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 “Unanticipated Inventory Build-Up Effects 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.

In our analysis, we distinguished between the switch from older legacy systems versus newer open standard and hybrid procurement technology solutions, and 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, Kriebel and Mukhopadhyay (1994). Yet the marketplace has been difficult, making it harder even for the reasonably well-established players to find the slack resources to subsidize any other players in the market. 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 B2B e-procurement 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 B2B platforms (such as open electronic B2B market exchanges) versus proprietary IOS systems, as well as some recently emerging hybrids. 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 limited adoption of B2B exchanges. Our model characterizes the latter solution as involving the choice of a technology 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. 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 standard B2B platforms (Meehan, 2001). Hence, our risk-adjusted transactions cost perspective seems especially appropriate in this context.

When firms take into account these procurement risks and uncertainties, we expect to see a pattern of behavior among firms in the presence of the new technologies: larger firms are more likely to trade off supply uncertainty with higher procurement costs and settle for proprietary IOS systems. They will tend to adjust the related transactions costs for the risks they face. Smaller firms will emphasize lower cost but less certain supply sources and opt for more open B2B platforms. Thus, despite the attractiveness of the open B2B platforms, both B2B and IOS systems are likely to coexist, consistent with evidence developed elsewhere by Dai and Kauffman (2002a). Our explanation for this coexistence relates to firm size, as firms' demand for both types of systems seems to be based on size.

We are also able to characterize the circumstances around which an open B2B technology platform for procurement may dominate existing 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 make. For example, there is a value-maximizing opportunity associated selecting “adaptable”
systems that can integrate with the retail 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 (such as those offered now by Ariba and CommerceOne, in conjunction with their strategic alliances with other vendors).

In addition to supply uncertainty, we have included demand uncertainty in our framework. This allows us to address the technology adoption behavior in the aftermath of the historical decline of the DotComs; supply disruptions also result in lower overall demand. 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 that we also predict is that the distinction between the procurement technology adoption patterns of the larger and smaller firms will actually intensify.

Our main result is ironic: the increased supply chain management cost sensitivity of the smaller firms is a consequence of their higher prior exposure to over-supply risks. Such firms are forced to take even greater risks to their lower procurement costs. We see these risks borne out in practice with the business press news about the difficulties that firms face to make their procurement technology investments and their adoption of B2B electronic market solutions pay off (Enos, 2001a and 2001b).

**Limitations**

One limitation of our model is its lack of consideration of investment timing and vendor selection tactics when the hybrid of mixed open and proprietary e-procurement solutions is selected. A second limitation is that we do not consider the possibility of vendor subsidies (as mentioned above) and the role of changing market psychology with respect to the upside benefits of B2B e-commerce procurement solutions. Vendor-side subsidies permit buyers and suppliers to consider adopting sponsored technologies, which develop network externalities and user side 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, Kriebel and Mukhopadhyay (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, figure among the DotComs whose equity prices and viability have been hard hit) to any extent. Clearly, vendor reputation and the future expectations of the market matter in this context, especially among new market entrants, where adopter expectations about future success are key.

In conclusion, we remind the reader of the following practical perspective:
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 normative guidance for senior managers about how to get these aspects of their B2B e-procurement technology decisions right.

REFERENCES


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