Information sharing in procurement occurs in many rich and varied industry contexts in which managerial decisions need to be made and organizational strategy needs to be formulated. This paper extends the theoretical results that are available to understand how information sharing ought to work in procurement contexts that involve investments in interorganizational information systems and collaborative planning, forecasting and replenishment practices. Our primary research question is: How and under what circumstances does a firm that plays the role of a buyer in supply chain management decide to share information on key variables, such as point-of-sale consumer demand data with its supplier, up the supply chain? The answers that we provide are based on the analysis of a sequential form game-theoretical model of buyer and supplier profits in the presence of uncertainties about final consumer demand, as well as the different operational cost regimes associated with information sharing and information withholding strategies, and the information technologies that support them. Our results provide normative guidance to supply chain buyers about how to interpret different demand uncertainty scenarios to improve the likelihood that their decisions will maximize the value of their firms.

**KEYWORDS:** Business-to-business e-commerce, economic analysis, electronic commerce, information sharing, organizational strategy, procurement, supply chain management, theory-building research, uncertainty.
INTRODUCTION

Recent increases in computing power have enabled algorithm-based optimization approaches for firms to manage uncertainties that arise in supply chain management as never before (Aviv, 2001; Kumar, 2001). This has prompted increasing systems and technological integration and information sharing across firms (Ball et al., 2002), as well as new managerial approaches, such as Web-based electronic data interchange (EDI), vendor-managed inventory and collaborative planning, forecasting and replenishment (Aviv and Federgruen, 1998; Seidmann and Sundararajan, 1997) and new contractual approaches in procurement (Cachon and Lariviere, 1999; Kleindorfer and van Wasselhove, 2003). All these approaches take advantage of the interdependent aspect of value that interorganizational information sharing can create for procurement of supplies in the presence of the appropriate business process capabilities (Riggins and Mukhopadhyay, 1994). Such arrangements create the possibility for different equilibrium pricing arrangements, and different terms set and agreed upon by buyers and suppliers.

Information sharing in procurement occurs in many rich and varied industry contexts in which managerial decisions need to be made and organizational strategy needs to be formulated. The common goals of firms in this context are effective inventory management and cost minimization when supply disruptions occur. In the former case, it is well known that firms must protect against the bullwhip effect, in which the effects of demand variability are amplified across the firms up the value chain (Lee, Padmanabhan and Whang, 1997). Yet, knowledge in this domain is often the buyer's strategic asset. Buyers benefit from the cross-functional value of information sharing, improving production planning and creating a basis for the transformation of marketing and sales strategy (Seidmann and Sundararajan, 1997). However, suppliers may use such information against buyers, tempering the latter’s desire to adopt IT and risk possibly losing competitive advantage in procurement (Whang, 1993). The result is that buyers will have a
diminished incentive to share information due to the risk exposure (Laffont and Tirole, 1999), while taking appropriate advantage of the strategic value of their private information (Chen, 1998; Gavirneni, Kapuscinski, and Tayur, 1999).

This paper extends the existing theoretical understanding of information sharing in e-commerce procurement contexts in supply chains. The paper’s focus is on information strategies of a buyer firm vis-à-vis its supplier, and thus the buyer’s decision regarding the adoption of information technology (IT) that involves sharing of information. It models the information strategies of a buyer in a supply chain and includes the possibility of withholding information upstream from its supplier because of the potential for supplier opportunism, where it is observed (Clemons, Reddi and Row, 1993; Seidmann and Sundararajan, 1997; Whang, 1993).

In the circumstances that we consider, we find that such information withholding strategies actually may yield full information, if the supplier is able to infer buyer’s private information, but may nonetheless leave the buyer worse off ex post, because of the buyer’s initial avoidance to invest in the appropriate ITs. This may leave the buyer better off if the supplier’s inference is incomplete, so that the final equilibrium is informationally inefficient. Should an information withholding strategy lead to a buyer being unwilling to adopt any IT, we have a classic application of the “asset hold-up” problem (Schmalensee and Willig, 1989).

In the food industry, Nakayama (2000) shows that information exchange plays a role in the power relationship between supermarkets and suppliers, impacting their trust and IT adoption among firms. An instance is when food retailers use EDI for inventory coordination. Suppliers’ knowledge of the buyer’s parameters leads them to monitor and control the buyer’s mark-up more effectively, reducing their incentive to share point-of-sale (POS) data with suppliers.

This source of incentive for the buyer to withhold information is different from the existing
understanding of the buyer’s incentives to distort order information when a supply shortage is anticipated, leading to the familiar bullwhip effect (Lee, Padmanabhan and Whang, 1997) or to exaggerate the forecast of final demand to induce supply to build larger capacity (Cachon and Lariviere, 2002). This issue has also been treated by economists in more general terms, related to inter-firm strategic information sharing in monopolistic, duopolistic, oligopolistic and competitive settings (e.g., Gal-Or, 1985; Li, 1985 and 1999; Raith, 1996). Other related studies in Operations Management include Lee, So and Tang (2000) and Gavirneni, Kapuscinski and Tayur (1999) and Cachon and Fisher (2000). The authors generally focus on the normative issue of the advantages of information sharing in reducing inventory and increasing supply chain efficiency, but do not discuss buyer incentives to withhold information. Whang (1993) studies information sharing from a different perspective, focusing on information “garbling” versus information sharing strategies of a supplier vis-à-vis its downstream buyer. Our perspective is different from these, but similar to another one offered by Li (2002). He focuses on information sharing and withholding strategies within the context of horizontal competition. The incentive of the buyer to share or withhold information from the supplier is driven by the leakage of information to potential rivals, rather than by supplier opportunism. We share with Li (2002) the notion of information inference stemming from the observed actions of the firm. But the inferring party in our analysis is the supplier, rather than competing buyers.

Another unique aspect of this paper is that the information sharing game that we specify takes place in an environment of uncertainty in which both the final demand facing the buyer and procurements that the buyer orders from its supplier are each subject to random shocks that are independent of each other. Thus our paper differs from a recent paper by Radhakrishnan and Srinidhi (2003) who consider demand side variability as the main influence; we consider an
independent procurement side variability due to random errors. For example, Dell reports a significant degree of statistical error in the procurement process that was reduced by sharing information with its suppliers: from 200 errors per million orders to just 10 (Perman, 2001).

We next turn to the development of a model that incorporates this consideration and enables us to understand the dynamics and the strategic considerations regarding IT adoption and information sharing. Our analysis will be accomplished in one preliminary and two analysis stages. There is a critical assumption in our work that does not appear in the others: all output pricing decisions for the firm will have a shorter time horizon than decisions about IT investments that permit information sharing. In the following section, we discuss some of the theoretical perspectives that provide a foundation for the analysis perspective and modeling approach that we will adopt throughout the paper. In the first stage, we develop several propositions on the impacts of managerial uncertainty relative to procurement. In the second stage, we analyze buyer-supplier information sharing by modeling the buyer's investment in information sharing via choices about the appropriate IT platform solutions as an outcome that is obtained in a sequential game in extensive form between the supplier and the buyer. The results are developed for three scenarios that capture the final consumer demand uncertainties that supply chain buyers face. We characterize the results with propositions that guide a managerial decisionmaker on how to think through the available strategy choices.

MODELING INFORMATION SHARING IN SUPPLY CHAIN MANAGEMENT

Different perspectives have developed in recent research on the appropriateness and implications of information sharing and the related strategies that firms develop. Lee and Whang (2000) note the trade-off that buyers in procurement must consider by asking: What is the minimum set of information to share with my supply chain partners without risking potential
exploitation? Gal-Or (1985) showed how information sharing can lead to results that may be socially efficient, creating greater value in the economy, even if they are not optimal from a specific firm’s point of view. Seidmann and Sundararajan (1998) analyzed how information sharing by firms along the supply chain can reduce costs and diminish vertical transactional inefficiencies. There may also be strategic implications, as horizontal information leaks may occur. Nakayama (2000) studied the strategic value of supply chain information in the food industry. He learned that buyer-supplier power is a driver of buyers’ willingness to adopt of EDI technology. Nakayama’s survey (2000) also finds that “there is evidence that power shifts towards suppliers with EDI links.” Kinsey and Ashman (2000) also have found that insufficient trust deters retail grocers from sharing critical information with their suppliers.

Other industries have seen similar considerations related to information and knowledge sharing arise as well. In retail banking, for example, Thakor (1999) has argued that early adoption of automated teller machines was driven by strategic considerations. Electronic banking systems adoption involving interorganizational sharing of ATMs was driven by such strategic considerations (Kauffman, McAndrews and Wang, 2000), as well as by the expected changes in transactions costs (Clemons and Kleindorfer, 1992).

In many supply chain contexts, the buyer is concerned about building bargaining or market power in the presence of choice about whether and how to share inventory information with suppliers. Suppliers tend to have market power relative to the buyer, even though there are cases (e.g., Dell, Wal-Mart and Target) where the buyer has close to monopoly power over the sellers. Both the buyer and supplier, however, face final demand uncertainties and procurement errors between orders and deliveries that they prefer to eliminate. We will focus on cases in which the supplier possesses market power relative to the buyer so we do not consider monopoly buyers.
However although the buyer is competitive with respect to the supplier, it is large enough to be able to exercise market power relative to its own customer base.

**Modeling Preliminaries**

We consider a competitive retail firm (i.e., the “buyer”) that exerts some price control on its products (i.e., acts as a price setter), but faces critical demand uncertainties. Buyer supplies are procured in a competitive market subject to supply uncertainties from the supplier, stemming from its own unavailability of goods, either due to inappropriate forecasting or production disruption or delays in delivery. The critical aspect is in the extent to which the buyer and the supplier face the possibility of procurement errors due to mismatched orders and deliveries, in terms of timing delay, incorrect specifications of the goods ordered, or incorrect quantities.

**Stochastic Demand and Supply Uncertainties.** Demand uncertainties arise because final sales are subject to stochastic shocks that managers cannot predict. To represent this, we let \( q_s - q_d = \delta q_s \Rightarrow q_d = (1 - \delta)q_s \), with \( \delta \sim f(0, \sigma_\delta^2) \) and \( \delta \in [-1,1] \). \( q_d \) is the final level of sales (or final demand, \( d \)), \( q_s \) is supply quantity received from wholesale supplier \( s \) and \( \delta \) is management estimation error (in relative terms) of final demand due to random shocks. The random variable \( \delta \) is symmetrically distributed with distribution \( f \), mean 0 and variance \( \sigma_\delta^2 \). To ensure that \( q_d \geq 0 \), the lower bound on \( \delta \) must be a truncated symmetric distribution (such as the truncated normal) in the interval [-1,1]. Supply uncertainties are modeled for a control variable, \( q_o \), that represents quantity to be ordered from a supplier, \( q_s - q_o = q_o u \Rightarrow q_s = (1 + u)q_o \), with \( u \sim g(0, \sigma_u^2) \) and \( u \in [-1,1] \). The distribution \( g \) can be any symmetric truncated distribution. Supply fluctuation sources are likely to be independent of any random demand fluctuations, so \( \text{cov}(\delta, u) = 0 \). Then, the variable \( q_o \) is the control variable that management wishes to optimize.

**Calculating the Buyer’s Profits.** A buyer \( b \)'s expected profits, \( E(\pi_b) \), are calculated by
integrating its objective function over two uncertainty dimensions, demand and supply, with
\( \pi_b(q_s, q_{df}) \) intended to represent the profit for a given supply quantity \( q_s \) and final consumer demand \( q_{df} \), prior to the application of the stochastic process operators:

\[
E(\pi_b) = \int_{-1}^{1} g(u)du \int_{-1}^{1} \pi_b(q_s, q_{df}) f(\delta) d\delta.
\]

(1)

To calculate expected profits, we evaluate the conditional expectation, \( E(\pi_b(q_d)) \), over \( q_{df} \):

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

(2)

In this expression, \( P(\bullet) \) is the inverse demand function, \( c \) is total unit cost of obtaining product from distributors, with product procurement cost, \( c_p \), and transaction cost, \( c_t \), of bringing the product to market (in terms of documentation, invoicing, advertisement). The supplier firm can exert market power over \( c_p \) while \( c_t \) is internal to the buyer firm. The parameter \( s \) denotes unit costs associated with excess or carry-over inventory and stock. It is intended to make the model more realistic by allowing for the possibility that the firm must absorb the costs of storing or disposing of inventory that was ordered in excess of that level necessary to meet final consumer demand.

We can express Equation 2 in \( \delta \) by noting \( 0 \leq \delta \leq 1 \) for \( q_s \geq q_{df} \) and \( 0 < \delta \leq -1 \) for \( q_s < q_{df} \),

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

(3)

This can be simplified because \( q_s \) is a given at this stage, and \( P(q_s)q_s \) is independent of \( \delta \). Since \( f(\delta) \) is symmetric in \( \delta \), and the integral covers half the range of \( \delta \), the first integral can be evaluated as \( [P(q_s)q_s]/2 \). We define the final term, the demand error integral, \( \Omega_\delta \), as,

\( \Omega_\delta = \int_{0}^{1} \delta f(\delta) d\delta \), so the buyer’s conditional profit expectation is:
Unanticipated Over-Supply. $\Omega_\delta$ represents the mean value of $\delta$, the extent that actual demand falls short of supply, i.e., $\delta > 0$. So $\Omega_\delta$ indicates the extent to which there is, on average, unanticipated over-supply or inventory build-up. Also, from $\delta \in (0,1)$, it follows that $\Omega_\delta < 1$. The unconditional value of expected profits is found by integrating the conditional expectation over the supply variance, $u$, to yield:

$$
E(\pi_b) = \int_{-1}^{1} E(\pi_b(q_s)) g(u) du.
$$

(5)

We can obtain an explicit form of $E(\pi_b(q_s))$, which will involve stochastic parameters, $\delta$ and $u$, as arguments of the inverse demand function $P[q_o(1+u)]$ and $P[q_o(1+u)(1-\delta)]$. Using Taylor series approximation of inverse demand around the non-stochastic order size, $q_o$, and integrating the results over the appropriate density functions, the buyer’s expected profit becomes:

$$
E(\pi_b) \simeq (1 - \Omega_\delta) P(q_o)q_o - (c + s\Omega_\delta)q_o + q_o^2 P'(q_o) A(\sigma_\delta^2, \sigma_u^2, \Omega_\delta).
$$

(6)

In this expression, the final term, $A(\bullet)$, involves the variance of the demand error integral and is

$$
A(\sigma_\delta^2, \sigma_u^2, \Omega_\delta) \equiv (1 - 2\Omega_\delta)\sigma_u^2 + \frac{\delta}{2}\sigma_\delta^2 (\sigma_\delta^2 + \sigma_u^2) - \Omega_\delta.
$$

Finding optimum orders $q_o^*$ requires the concavity of expected profits, $E(\pi_b)$. This imposes a limit on unanticipated overstock size, $\Omega_\delta$, so that

$$
\frac{d^2 E(\pi_b)}{dq_o^2} < 0 \Rightarrow \Omega_\delta < \frac{1}{2} \left(1 + \frac{\sigma_\delta^2}{2}\right).
$$

The Buyer’s Optimizing Behavior in the Presence of Linear Demand

We begin with a brief analysis of the buyer’s order level selection, $q_o$, to maximize expected profits. We examine the case of linear demand, with $P(q_o) = a - zq_o$. This demand structure supports a tractable illustrative analysis. The first order condition for optimization yields:
\[ \frac{dE(\pi_b)}{dq_b} = 0 \Rightarrow q_o^* = \frac{1}{2z} \frac{(a-c)-(a+s)\Omega_\delta}{(1+\sigma_u^2)(1+\frac{1}{2}\sigma_\delta^2 - 2\Omega_\delta)}. \] (7)

From the expression for \( q_o^* \) presented earlier, we know that maximum expected profits are:

\[ \pi_b^* = \frac{1}{4z} \frac{[(a-c)-(a+s)\Omega_\delta]^2}{(1+\sigma_u^2)(1+\frac{1}{2}\sigma_\delta^2 - 2\Omega_\delta)}. \] (8)

If the buyer firm is to remain viable in the marketplace, its optimum order size and profits must be positive. Since the denominators of Equations 7 and 8 are positive (by the concavity of expected profits), the firm is viable if the numerator in Equation 7 is positive, i.e., if unanticipated overstock has an upper bound, \( \Omega_\delta < \frac{a-c}{a+s} \). Thus, \( \Omega_\delta \) is limited by \( \min\left[\frac{1}{2} \left(1 + \frac{\sigma_u^2}{2}\right), \frac{a-c}{a+s}\right] \).

In Equations 7 and 8, supply and demand uncertainties, \( \sigma^2_\delta \) and \( \sigma^2_u \), affect expected output and profits adversely, as would be expected, \( \frac{\partial \pi_b^*}{\partial \sigma^2_\delta}, \frac{\partial \pi_b^*}{\partial \sigma^2_u} < 0 \) and \( \frac{\partial q_o^*}{\partial \sigma^2_\delta}, \frac{\partial q_o^*}{\partial \sigma^2_u} < 0 \). However, the effect of the unanticipated over-supply parameter, \( \Omega_\delta \), is mixed, exerting opposite influences via the numerator and the denominator of Equations 7 and 8. The origin of this is found in the expression for expected profits, Equation 6: \( \Omega_\delta \) affects expected profits adversely via the revenues and inventory costs, which are the first two terms in the expression. But it also positively affects expected profits through the slope of inverse demand \( P'(q_o) \), which is negative. This is tied to the market power of the buyer. For a competitive buyer \( P'(q_o) = 0 \) and unanticipated oversupply, \( \Omega_\delta \), reduces expected profits unambiguously. However, buyers 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., \( q_s > q_d^f \), or \( \delta > 0 \), moderating the adverse effect of overestimating the demand. This leads us to assert:
Proposition #1 (The Market Power Proposition): Buyer firms that have greater market power with respect to their final consumers are better able to absorb adverse effect of oversupply shocks by reducing prices than those with little or no market power.

The overall net effect of inventory overstock is negative, $\frac{\partial \pi_{e}}{\partial \Omega_\delta} \frac{\partial q_{e}}{\partial \Omega_\delta} < 0$, if $\Omega_\delta$ has an upper bound, $\Omega_\delta < 1 + \frac{1}{2} \sigma_u \sigma_{\Omega}^2 - \frac{a - c}{a + s}$.

The Supplier’s Optimizing Behavior Relative to the Buyer

We next analyze the optimizing behavior of the supplier relative to the buyer. To do this, we first decompose the unit cost into its components, the procurement cost and the transaction cost, $c = c_p + c_t$, as in the context of our calculation of the buyer’s profits. We assume that the seller possesses market power and acts monopolistically with respect to the buyer. This is reflected in the supplier’s ability to influence the procurement costs, $c_p$, that it charges the buyer. The supplier’s resulting profits are given by:

$$E(\pi_s) = (c_p - v)E(q_s(c))$$

(9)

where $v$ is the unit cost of production, and $q_s = (1+u)q_o(c)$ captures uncertainty in the source of supply. The function $q_o(c) = \frac{1}{2z} \frac{(a-c)-(a+s)\Omega_\delta}{(1+\sigma_u^2)(1+\frac{1}{2}\sigma_{\Omega}^2 - 2\Omega_\delta)}$ is determined by Equation 7. Thus, Equation 9 shows a Stackelberg supplier that acts as a “leader,” observing the buyer's downward sloping demand, as a function of the unit cost of procurement, $c$. Substituting from $q_s = (1+u)q_o(c)$ into Equation 9, the supplier's expected profits become:

$$E(\pi_s) = \int_{-1}^{1} (c_p - v)q_o(c_p + c_i)(1+u)g(u)du = (c_p - v)q_o(c_p + c_i)$$

(10)

Obviously, the effect of product costs charged by the supplier is positive on supplier profits to the extent they can be passed on to the buyer, due to $c_p - v$ in Equation 10. But we also know...
from the expression, \( \Omega \Delta < \frac{a - c}{a + s} \), that this effect is negative to the extent that it can trigger an adverse demand response on the part of the buyer firm via \( q_o (c_p + c_t) \). Substituting for \( q_o(c) \) from Equation 8 and remembering that \( c = c_p + c_t \), balancing these effects means that the supplier charges the buyer:

\[
\frac{dE(\pi_s)}{dc_p} = 0 \Rightarrow c_p^* = \frac{1}{2} \cdot [a - c_t - (a + s)\Omega \Delta + v]
\]  

(11)

Notice that an increase in \( \Omega \Delta \) via \( \frac{\partial c_p^*}{\partial \Omega \Delta} < 0 \) reduces the optimum charge by the wholesaler to the buyer. This leads to our second proposition:

- **Proposition 2 (The Procurement Cost-Overstock Link Proposition):** The procurement cost that the supplier firm charges its downstream client firm is inversely related to the size of the overstock facing the buyer firm.

Substituting from Equations 8 and 11 into Equation 10 yields an expression for the supplier’s maximum expected profits (analogous to what we computed for the buyer):

\[
\pi_s^{e^*} = \frac{1}{4z} \cdot \frac{(a - c_t + v)^2 - [(a + s)\Omega \Delta - \frac{vs}{a + s}]^2 + (\frac{vs}{a + s})^2}{(1 + \sigma_u^2)[1 + \frac{1}{2}\sigma_s^2 - 2\Omega \Delta]}
\]  

(12)

This expression raises a number of key issues that deserve discussion. **First**, as in the case of the buyer, supplier profits fall with uncertainty in final demand facing the buyer and the uncertainty associated with the variance between the supply of goods and buyer’s orders, based on the second derivatives, \( \frac{\partial \pi_s^e}{\partial \sigma \Delta}, \frac{\partial \pi_s^e}{\partial \sigma_u^2} < 0 \). Thus, our analysis shows that the buyer and seller along the supply chain benefit from a reduction in the market variance as well as improved coordination between orders and deliveries. **Second**, the effect of unanticipated overstock at the level of final sales to the consumer is affected different ways: negatively through the numerator...
and positively via the denominator. To gauge the overall effect, we need to consider the expression for the supplier’s expected profit, $E(\pi_s)$ from Equation 10. Differentiating this equation when it is evaluated at the optimum in $\Omega_\delta$, we get:

$$\frac{\partial \pi_s^{*\pi}}{\partial \Omega_\delta} = \frac{\partial E(\pi_s)}{\partial \Omega_\delta} = \frac{\partial c^*_{p \delta}}{\partial \Omega_\delta} q^*_{o \delta} (c^*_{p \delta} + c_i) + (c^*_{p \delta} - v) \frac{\partial q^*_{o \delta}}{\partial \Omega_\delta}$$  \hspace{1cm} (13)

We know that $\frac{\partial c^*_{p \delta}}{\partial \Omega_\delta} < 0$, so that an increase in uncertainty $\Omega_\delta$ causes the optimum charge by the supplier to the buyer to fall, the first term in Equation 13. The second term of Equation 13 whose negative sign we established before, $\frac{\partial q^*_{o \delta}}{\partial \Omega_\delta} < 0$, suggests that the effect of uncertainty $\Omega_\delta$ on the buyer’s order size is negative, so long as $\Omega_\delta < 1 + \frac{1}{2} \sigma^2_u - \frac{a - c}{a + s}$ holds, as we discussed earlier. Thus, we can conclude that $\Omega_\delta$ also adversely affects seller firm’s profits, $\frac{\partial \pi_s^{*\pi}}{\partial \Omega_\delta} < 0$. We summarize this result as follows:

- **Proposition #3 (The Uncertainty Reduction-Profitability Link Proposition):** The seller firm’s profit level is adversely affected by demand and supply uncertainties and by the unanticipated excess inventory build-up facing the buyer down the supply chain. Thus, a reduction in the demand and supply uncertainties and the excess overstock of the buyer firm will also improve both the buyer and the supplier firm’s profits.

**Interpretation**

This finding is important for several reasons. It explains the mechanism by which the recent inventory among large retail firms (e.g., Hewlett-Packard/Compaq, Dell, Best Buy, etc.), led by the slowdown in consumer spending, reverberates through the supply chain, causing a more generalized slowdown and a decline in profitability. In addition, combined with the Procurement
Cost-Overstock Link Proposition, and the inequality, $\frac{\partial c^*_p}{\partial \Omega_\delta} < 0$, we obtain an explanation for why firms may be concerned about the consequences of adopting information technologies that may lead to sharing information. This seems to be what is happening in the food industry.

Nakayama (2000) reports that the buyer’s adoption of collaborative planning, forecasting and replenishment (CPFR) systems, which employ EDI for inventory coordination, results in tighter control of the buyer's mark-up capacity by their suppliers. This effectively raises the buyer's costs. Interestingly, this is exactly what happens in the model we have analyzed. A decline in unanticipated overstock, $\Omega_\delta$, due to better knowledge of the market, contributes to the buyer’s profits in the short run, but raises the cost that the supplier charges the buyer, due to the opportunistic behavior on the part of the supplier. Together these adversely affect the latter’s profits. By the same token, a better forecast of final demand and the resulting decline in the value of $\Omega_\delta$, tend to improve the supplier’s profits. This finding is echoed in the paper by Seidman and Sundararajan (1998). As a result, the supplier may have an incentive to subsidize the buyer’s adoption of information sharing technologies and technology platform strategies (Riggins, Kriebel and Mukhopadhyay, 1994 and 1995; Riggins and Mukhopadhyay, 1999) such as CPFR and vendor-managed inventory. This is Nakayama’s (2000) observation: sharing inventory data reduces uncertainties associated with supply, and benefits the buyer and supplier.

Consider the perspectives of the buyer and supplier in other settings. Although they may be able to gain from information sharing, there are still ways in which they will be in conflict. In our model, procurement costs play that role. Since sharing information begins with the buyer in these cases, there may be some reluctance on the part of the buyer to engage in information sharing, especially if the expected loss from sharing information exceeds the expected gains.
The question is then to understand the circumstances under which an information sharing strategy dominates an information withholding strategy in the game between the buyer and the seller. We next will expand on the initial model to incorporate the buyer’s aversion to the potentially damaging loss associated with sharing information.

ANALYZING INFORMATION SHARING IN A SEQUENTIAL GAME

Our emphasis now shifts to the analysis of buyer-supplier information sharing optimization in collaborative planning, forecasting and replenishment (CPFR) systems. We focus on the buyer's decision to accept or reject making this investment in the context of a sequential game-theoretic model in extensive form between the supplier and the buyer. (See Figure 1.)

Figure 1. A Sequential Form Game Theory Model for CPFR Information Sharing

Note: Adoption of EDI and CPFR permits the buyer to drive the value of the demand error integral $\Omega_0$ to 0, but the operational costs of matching orders to demand remain. Path 1 is the information sharing strategy path, and results in net long-run expected profit for the buyer of $\Gamma_1$. Path 2 is the information withholding strategy path for the buyer. The ong-run expected profit associated with this decision is $\Gamma_2$. Along Path 1, the information of the buyer and the supplier are the same. However, along Path 2, the buyer decides to procure without sharing its private information about final demand, with the result that the supplier and the buyer will have asymmetric information.
A key assumption of our approach is that the output pricing decision has a shorter time horizon than the decision on IT investment. This permits us to model output the pricing decisions contemporaneously and the IT adoption decision sequentially. Formal game-theoretic approaches such as those we employ here have been utilized in other contexts to study strategic IT adoption by firms (e.g., Dewan, Jing and Seidmann, 2000; Riggins, Kriebel and Mukhopadhyay, 1994 and 1995, among others).

The difference in the time horizon between the two decisions means that the buyer may act strategically with respect to its supplier, even as it acts myopically with respect to prices and quantities. In our model, the buyer observes the dependence of procurement costs, $c_p$, on unanticipated over-supply, $\Omega_\delta$. The buyer’s profits arising from this strategic behavior is found by substituting the supplier’s cost Equation 11 into the buyer’s profit Equation 8:

$$\pi_b^* = \frac{1}{4b} \left[ \frac{(a - c_p^* - c_i) - (a + s)\Omega_\delta}{(1 + \sigma_u^2)(1 + \frac{1}{2} \sigma_\delta^2 - 2\Omega_\delta)} \right] c_p^* = \frac{1}{2} \left[ a - c_i - (a + s)\Omega_\delta + v \right]$$

(14)

**Strategy Options for the Buyer**

This analysis leads to several strategic options for the buyer firm. The most interesting one is where the buyer firm has the incentive to use information on final demand (e.g., through point-of-sale data from stores) to raise its own profits, but to withhold information from its supplier to keep down that part of product's procurement cost, adversely affecting the latter’s profits.

Another option that is available to the supplier is to increase the buyer’s incentive to adopt by subsidizing the investment costs associated with procurement platform information sharing solutions. Whether the buyer firm accepts or rejects this offer will depend on the supply chain environment, including the size of the critical parameters (e.g., firm size, investment cost, etc.) and the degree of uncertainty in market demand. Even in the absence of the buyer’s adoption of CPFR, the supplier still may be able to extract information from the buyer based on the latter's
periodic order quantities. The subgame perfect equilibria arise from the buyer’s choice of the most profitable strategy—whether to adopt CPFR and share information, or not—given the supplier’s response to the strategy.

**Assumptions.** We assume the buyer gathers consumer and market data by means of POS scanners. The data do not automatically help to reduce the size of the estimated error in final demand, $\sigma^2_\delta$ and the unanticipated over-supply, $\Omega_\delta$, unless the retail firm has adopted other technologies to analyze and interpret the market data. We further assume that the buyer has adopted IT capabilities that permit effective internal use of shared information, and EDI for communication with the supplier. The adoption of internal IT capabilities and EDI cause the buyer’s costs of handling supplies, $c_s$, to decline, and it is able to forecast demand more effectively, reducing uncertainty. This causes the variance of the demand error forecast, $\sigma^2_\delta$, and the unanticipated over-supply, $\Omega_\delta$, to fall.

For simplicity, we also will assume that demand-related uncertainty is eliminated, so that the demand error forecast, $\sigma^2_\delta$, and the anticipated over-supply $\Omega_\delta$ will be equal to zero. The drop in demand uncertainty benefits the buyer as we have seen. This will benefit the supplier, as we have seen, if the buyer is willing to enter into *full-fledged information sharing* of market information and data with the supplier, as with CPFR adoption. Another immediate advantage of full-fledged information sharing is the reduction in supply uncertainties that arise form supply chain coordination under CPFR, so that $\sigma^2_\nu$ also goes to zero. Information sharing is beneficial to the seller in both respects.

**Buyer and Supplier Impacts.** The buyer faces some trade-offs, however. He benefits from the reduction in supply and demand uncertainties. But sharing final demand information with the supplier increases the supplier’s ability to exercise market power over the buyer via product
procurement costs, \( c_p \). For this reason, the buyer may be reluctant to share this market information with the seller despite the informational gains of information sharing to both sides. The evidence suggests that the supplier may be willing to subsidize the buyer in its sharing of this information, e.g., in the food industry (Nakayama, 2000). Riggins, Kriebel and Mukhopadhyay (1994), and Seidmann and Sundarajan (1998) model transfer payments of this type in supply chain management.

The buyer’s decision about whether to accept or reject an offer by the supplier to share information using CPFR will depend on parameters describing the business environment of the B2B relationship. If the buyer rejects the supplier’s offer, then the former will continue to rely on its own internal systems (such as its enterprise system or internal forecasting capabilities), and not have access to CPFR. Enterprise systems use EDI capabilities for ordering and logistics between the supplier and buyer. So if the buyer fails to adopt CPFR, but it still has these other capabilities, then its ability to obtain and share information will be incomplete, and will not extend to the most sensitive market data.

**The Buyer’s Adoption of the Supplier’s Offer of CPFR: Information Sharing**

The general expression for the buyer’s profits with respect to its observation of the dependence of procurement costs, \( c_p \), on the unanticipated over-supply \( \Omega \) was presented in Equation 14. The buyer’s strategy options are based on evaluating the associated profit stream under different informational schemes. We will evaluate *net long-run profits*, by taking into account the amortized fixed cost of IT. We first analyze the case in which the buyer adopts the CPFR approach that the supplier offers. With full-fledged information sharing through CPFR, we are effectively assuming that the supply and demand error variances are eliminated, as shown by Path 1 in Figure 1. When this is the case, the buyer’s profit function becomes:
\[ \pi_b^{e^*} \mid \text{info sharing} = \pi_b^{e^*} \left( \Omega_\delta = 0, \sigma_\delta^2 = 0, \sigma_u^2 = 0, c_i < c_i' \right) = \frac{1}{16z} (a - c_i' - \nu)^2 \] (15)

The buyer's net long-run profit, \( \Gamma_1 \), from this decision is its equilibrium profit from Equation 15, adjusted downwards for the annualized cost to finance the fixed cost of adoption. If \( r \) is the interest rate, \( F_1 \) the fixed cost of an enterprise system, and \( F_2 \) the fixed cost of IT to support additional internal analysis of the information that the supplier shares with the buyer (e.g., category management), the net long-run profit for Path 1 for the buyer is:

\[ \Gamma_1 = \frac{1}{16z} (a - c_i' - \nu)^2 - r(F_1 + F_2) \] (16)

**The Buyer’s Rejection of the Supplier’s Offer of CPFR: Asymmetric Information**

This case, described by Path 2 in Figure 1, is interesting to analyze because it can explain the observed anomalous behavior in the supply chains. We pointed out earlier that buyers in supply chain management operations tend to underinvest in IT that promotes information sharing because they are concerned about such issues as trust and the sharing of benefits. Traditional retailers have been especially concerned about issues of trust, and especially whether sharing consumer demand and inventory state information for the purposes of procurement and replenishment might threaten profitability when potential rivals exploit this private information for their own gain. In the food industry this issue has been particularly significant. Kinsey and Ashman (2000) point out that this may be why market leaders that have adopted product bar codes and scanner technology have lagged behind in the adoption of e-procurement and information-driven replenishment practices such as CPFR.

We can explain this by recognizing the extent to which information is a strategic asset for the firm, to be guarded and, at times, even withheld, when circumstances warrant. Consider
\[ \frac{dB(\pi_c)}{dc_p} = 0 \text{ and } \frac{\partial c^*_p}{\partial \Omega_\delta} < 0. \] The unit cost of procurement, \( c_p \), rises to the buyer as a result of smaller values of the demand forecasting error integral, \( \Omega_\delta \), representing a reduction in unanticipated over-supply. So we see that improved information to the supplier as a result of CPFR-type information sharing arrangements has the paradoxical potential to raise the buyer’s costs. Thus, buyers who act strategically with respect to information sharing would observe this adverse dependence on procurement costs arising due to the information sharing arrangements with the supplier. Thus, the buyer may find it beneficial to withhold sales information from the supplier, foregoing the benefits of CPFR in terms of inventory coordination with the supplier, so that \( \Omega_\delta \) will stay the same, and choosing to reject CPFR as a profitable IT strategy.

Therefore, although the supplier remains uncertain about the state of final demand facing the buyer, the buyer still can estimate its final demand without undue uncertainty by adopting other more internally-focused IT approaches (e.g. enterprise systems and category management) for use with its own POS scanner data. The buyer’s decision to withhold its data as proprietary information means that it will now be different from the supplier's, leading to an information asymmetry. The buyer’s profits under this strategy arise from evaluating the maximum expected value of the buyer’s equilibrium profits in Equation 14. We take special care to distinguish the information uncertainty experienced by the buyer, \( \Omega_\delta^b \) and \( \sigma_\delta^2 \), from that of the supplier, \( \Omega_\delta^s \) and \( \sigma_\delta^2 \). In the maximization of the buyer’s expected profits in Equation 8, the buyer’s own information effect enters directly, but the information effects from the wholesaler operate only via the unit cost parameter, \( c_p^* \). To be consistent with our presentation of the full-fledged information sharing case, we present the buyer’s expected profit function for the no information sharing case in a similar manner based on Equation 14:
The supplier perceives a demand error integral value, \( \Omega_{\delta}^{s} \), for anticipated over-supply. The reader should also notice that similar to the information sharing strategy, the internal transaction costs to the buyer, \( c_{t}' \), are less due to its internal IT investments. The supplier is aware of this lower transaction cost and uses \( c_{t}' \) to evaluate \( c_{t} \), which appears as \( c_{p}^{*} \) in Equation 17, the procurement cost expression, and also directly in the profit term. The amortized fixed costs of the related IT are the same as in the information sharing strategy. Evaluating Equation 17, the net long-run profit from adopting an asymmetric information strategy, \( \Gamma_{2} \), is:

\[
\Gamma_{2} = \frac{[(a - c_{p}^{*} - c_{i}) - (a + s)\Omega_{\delta}^{s} - \frac{(a - c_{i}) + (a + s)\Omega_{\delta}^{s}}{\sigma_{u}^{2}} + \frac{\sigma_{u}^{2}}{2} - \sigma_{u}^{2} = 0, \sigma_{u}^{2} = 0, c_{i}' < c_{i}]}{16b(1 + \sigma_{u}^{2})} - r(F_{1} + F_{2}) \tag{18}
\]

So, it appears that the net long-run expected profit for the buyer \( \Gamma_{2} \) rises with \( \Omega_{\delta}^{s} \).

□ **Proposition 4 (The Buyer’s Information Withholding Proposition):** The effect of a buyer withholding proprietary market information from its supplier is to increase the buyer’s profits, all else equal.

Compared to the information sharing strategy payoff in Equation 15, the price paid for the buyer's refusal to share information is the supply uncertainty and poor procurement coordination, represented by \( \sigma_{u}^{2} \). We next discuss the equilibrium value of \( \Omega_{\delta}^{s} \) and examine this trade-off.

**EQUILIBRIUM ANALYSIS FOR THE ASYMMETRIC INFORMATION STRATEGY**

Before we can examine what the outcome of this game will be for the supplier and the buyer, the nature of the information that they possess must be more closely examined. In this section, we discuss what determines the equilibrium value of the demand error integral for the supplier, \( \Omega_{\delta}^{s} \), and further examine what is involved in the analysis of the trade-offs.
Revealed Equilibrium Signal with Asymmetric Information: Case of Multiple Equilibria

The key aspect of the asymmetric information exchange between the buyer and the supplier turns out to be that despite the buyer's withholding of sensitive final demand data from the supplier, the latter will is still able to extract some valuable information from the buyer. This occurs because the exchange is based on orders arriving from the buyer that must be filled by the supplier. To see this, we begin by noting that market equilibrium between the buyer and the supplier arises if an expectation realization condition is satisfied: namely, that the expected quantity of orders forecasted by the supplier matches the certainty equivalence level of orders by the buyer. This equality comes from applying the expression for the optimal order quantity,

\[ q_s^* = \frac{1}{2z} \cdot \frac{(a-c)-(a+s)\Omega_s}{(1+\sigma_u^2)(1+\frac{1}{2}\sigma_s^2 - 2\Omega_s)} \]

There, \( q_s^* \) is the order quantity expected by supplier and \( q_b^* \) is the order quantity received from buyer.

The unit cost, \( c \), in the expression for \( q_0^* \), consists of a transaction cost component and a procurement cost component, and depends on the demand-related error integral, \( \Omega_s \), as in Equation 17. The superscript \( s \) is the uncertainty as seen from the perspective of the supplier.

Yet, in fact, \( c_p(\Omega_s^s) \) shows up to both parties in the same way. Why? On the one hand, the supplier has access only to information it perceives. On the other hand, the buyer knows this to be the case for the supplier. So this suggests that although the supplier acted strategically in terms of supply quantity, the buyer is able to act strategically with respect to the signals that are present in the game. Beyond that, however, the buyer operates on the basis of its own information, \( \Omega^b \) and \( \sigma^b \). Finally, we assume that the buyer has access to full information.
about the market in which final consumer demand is established (which it withholds from the supplier), so that \( \Omega^r_\delta = (\sigma^r_\delta)^2 = 0 \), while \( \Omega^s_\delta = (\sigma^s_\delta)^2 = 0 \). The demand error integral, \( \Omega^s_\delta = 0 \), allows for the possibility that the supplier’s knowledge of the market facing the buyer through the procurement process is complete. Equation 19 has two roots, one of which corresponds to complete information. These are \((\Omega^r_\delta)_1 = 0\) and \((\Omega^r_\delta)_2 = \frac{2}{2-\alpha} \frac{a-c'_v}{a+s}\), respectively, where \(\alpha\) is a constant less than 1. The parameter \(\alpha\) is characteristic of the underlying density function. We assumed that \(1/2(\sigma^s_\delta)^2 = \alpha \Omega^s_\delta\) with \(\alpha < 1\), to eliminate \((\sigma^s_\delta)^2\) in favor of \(\Omega^s_\delta\). This assumption is based on the definitions of \(\Omega^s_\delta = \int_0^1 \delta f(\delta)d\delta\), and \(\sigma^s_\delta^2 = \int_{-1}^1 \delta^2 f(\delta)d\delta\), and the fact that \(\delta^2 < \delta < 1\). Figure 2 depicts the quantity curves for the two-sided certainty equivalent in Equation 19, as well as their intersection associated with the two solutions.

**Figure 2. Determination of Information Equilibrium in Supply Chains**
With an increase in informational asymmetry $\Omega_\delta$ due to information that is withheld from the supplier but is available to the buyer, the quantity ordered by the buyer rises, but the quantity expected by the supplier falls, though with a discontinuity at $1/(2-\alpha)$. (There is also a case in which $q^*_{\theta | \text{order quantity expected by supplier}}$ rises with $\Omega_\delta^*$. However, we rule this case out since it leads to the result that $2-\alpha < \frac{a-c_i'-v}{a+s}$. This is impossible since $2-\alpha > 1$, while $\frac{a-c_i'-v}{a+s} < 1$.) For the supplier’s expected quantity to fall in $\Omega_\delta^*$ we must have $1/(2-\alpha) > (a - c_0' - v) / (a+s)$. This guarantees that the second root of Equation 19 is positive, i.e., $(\Omega_\delta^*)_2 > 0$. But it also guarantees that $(\Omega_\delta^*)_2 > 1/(2-\alpha)$.

Thus, the discontinuity separates the two equilibria, i.e., we have a case of separating multiple equilibria. Since the solutions are separated by this discontinuity, it follows that the initial level of informational asymmetry determines which equilibrium value of $\Omega_\delta^*$ is reached. This is an instance of what we have referred to as a path dependency.

**Information Convergence and Separating Equilibria**

Our model is an example of a class of models in Economics that are known as signaling models (e.g., Spence, 1973, who discusses job market signaling via educational levels). Buyers have the capability to signal the expected state of final consumer demand through the orders that they place up the supply chain. Suppose the buyer begins with an initial level of market uncertainty corresponding to the mean unanticipated over-supply of $\Omega_\delta^\theta$. As the buyer reveals information about the market to the supplier, the level of uncertainty perceived by the supplier $\Omega_\delta^s$ will gradually decline from its original level of $\Omega_\delta^\theta$. But where does the final equilibrium solution occur? The answer depends on the relative size of $\Omega_\delta^\theta$ compared to the discontinuity point of $(\Omega_\delta^s)_{\text{Discontinuity}} = 1/(2-\alpha)$. We distinguish among three scenarios:
□ **Scenario A (Low Market Uncertainty).** Initial market uncertainty is very small such that $(\Omega_s^* \delta^*)_1 = 0 < \Omega^o_\delta < 1/(2-\alpha) < (\Omega_s^* \delta^*)_2$. In this case, $(\Omega_s^* \delta^*)_1 = 0$ will be binding and the supplier’s inference will lead to full information convergence.

□ **Scenario B (Intermediate Market Uncertainty).** Initial market uncertainty is of intermediate size such that $(\Omega_s^* \delta^*)_1 = 0 < 1/(2-\alpha) < \Omega^o_\delta < (\Omega_s^* \delta^*)_2$. If this is true, then $1/(2-\alpha)$ will be binding and the supplier’s inference leads to information convergence.

□ **Scenario C (High Market Uncertainty).** Initial market uncertainty is large such that $(\Omega_s^* \delta^*)_1 = 0 < 1/(2-\alpha) < (\Omega_s^* \delta^*)_2 < \Omega^o_\delta$. In this setting, $(\Omega_s^* \delta^*)_2$ will be binding and the supplier’s inference converges to this point.

Note that because of the underlying discontinuity in supplier profits in Figure 2, the convergence of information will be towards either $(\Omega_s^* \delta^*)_1$ or $(\Omega_s^* \delta^*)_2$ (depending on the position of $\Omega^o_\delta$) but not both. We summarize these results in the following proposition.

□ **Proposition 5 (The Inferred Equilibrium Proposition).** If market uncertainty is low, then supplier inference from the buyer’s orders leads to an equilibrium with full information $(\Omega_s^* \delta^*)_1 = 0$ (Scenario A). If market uncertainty is moderate then supplier inference leads to an equilibrium so some uncertainty facing the supplier still remains and is equal to $1/(1-\alpha)$ (Scenario B). If market uncertainty is higher, then supplier inference leads to an equilibrium with greater residual uncertainty equal to $(\Omega_s^* \delta^*)_2$ (Scenario B).

These results suggest that high information asymmetry cannot be rectified in a market with a high degree of uncertainty, but it can be when the uncertainty is less. Overall, information withholding strategies are more harmful in markets with high levels of uncertainty than limited uncertainty. This may be why information sharing is greater when market variance is greater (e.g., electronics, airlines, travel) than when it is lesser (e.g., food, construction supplies).

**Strategy Dominance and Information Convergence**

When should the buyer switch strategy? We consider the profit streams of the buyer under the information sharing strategy and the information withholding strategy. (See Figure 3.)
**Figure 3. Information Sharing and Information Withholding Strategies**

**Cases A1 and A2:** $\Omega \delta < \Omega^T \delta$.
Then $\Gamma_2 (\Omega \delta) < \Gamma_1$ and information sharing always dominates.

**Case B:** $1/(2-\alpha) > \Omega \delta > \Omega^T \delta$. Full information convergence. Information is initially withheld but dominates in equilibrium.

**Case C1:** $\Omega^\alpha \delta > \Omega^T \delta > (\Omega \delta)^*_2$. Partial information convergence to $(\Omega^\alpha \delta)^*_2$. Information is initially withheld but sharing dominates in equilibrium.

**Case C2:** $\Omega \delta > (\Omega \delta)^*_2 > \Omega^T \delta$. Partial information convergence to $(\Omega^\alpha \delta)^*_2$. Information withholding dominates initially and in equilibrium.
We view both as a function of uncertainty, and use them to characterize when a switching strategy is appropriate. Under the information sharing strategy this demand-based uncertainty is eliminated so that the net long-run expected profit for the buyer, $\Gamma_1$, becomes a flat line, corresponding to Equation 15. However, under the information withholding strategy, when the buyer has access to information but does not share that with the supplier, the buyer’s profits, $\Gamma_1$, increase with market uncertainty, as suggested by Equation 16. The two profit functions intersect at a point on the demand error integral axis—say $\Omega_T^\delta$—that defines the threshold value of market uncertainty for switching IT strategies, as follows:

$$\Omega_T^\delta = \frac{[1 + \sigma_u^2]^{1/2} - 1][a - c - r - v]}{a + s}$$ (20)

When we compare $\Omega_T^\delta$ with the second root $(\Omega_s^\delta)_{2}$ solution to the certainty equivalence expression in Equation 19, we find that, depending on (a) the positions of two information parameters, i.e., the initial market uncertainty $\Omega_o^\delta$ and the switching uncertainty $\Omega_T^\delta$, and (b) the initial profit advantage of the information withholding strategy, three outcomes are possible: that strategic value of the information withholding vanishes, is actually reversed, or its relative margin diminishes but it remains dominant. We distinguish three scenarios:

- **Scenario A (Low Market Uncertainty):** $\Omega_o^\delta < \Omega_T^\delta$. Then $\Gamma_2 (\Omega_o^\delta) < \Gamma_1$. In this case an information sharing strategy always dominates. (See Figure 3, Cases A1 and A2.)

- **Scenario B (Intermediate Market Uncertainty):** $1/(2-\alpha) > \Omega_o^\delta > \Omega_T^\delta$. In this case, information is initially withheld but the information withholding “rent” dissipates in the long run, due to information leakage to the supplier. There is full information convergence. (See Figure 3, Case B).
Scenario C (High Market Uncertainty): $\Omega^s_\delta > \max[\Omega^{T_\delta}, (\Omega_\delta^s)^2] > 1/(2-\alpha)$. Then $\Gamma_2 (\Omega^s_\delta) > \Gamma_1$. Case C1 is similar to Case B in that an information withholding strategy dominates initially but the information withholding “rent” dissipates in the long run and in fact reverses, due to information leakage to the supplier. However, unlike Case B, information convergence is partial. In Case C2, the information rent is can be sustained maintained even in the long-run. (See Figure 3, Cases C1 and C2.)

Cases B and C1 are particularly interesting. Here, the buyer withholds information from the supplier, yielding greater initial profits. However, due to the supplier’s learning and inference, information convergence leads to a new equilibrium profit that is so much lower as to make an information withholding strategy inferior to the outcome for the firm if it had implemented an information sharing strategy to begin with. This path dependence arises because the firm’s benefits of information sharing strategy are no longer available while the benefits of information withholding strategy vanish due to learning and inference by vendor firm. To summarize:

Proposition 6 (The Buyer’s Feasible Strategy Proposition). Information sharing or withholding strategies may both be feasible strategies for the buyer. However, in some circumstances a buyer’s information withholding strategy locks him into a path-dependent lower long-run profit, due to information leakage to the supplier.

CONCLUSION

The emergence of supply chain strategies and technologies has contributed to the cost reductions and increased procurement coordination that we have observed over the past few years across many industries. Yet, the continued expansion of supply chain practices depends in large measure on firms’ willingness to share what they view as sensitive information about demand, operating costs, and their customer relationships. How likely is the continued adoption
of IT-based supply chain practices, in the light of firms’ efforts to achieve an appropriate balance between profit-maximizing sharing or withholding of inventory and sales information?

We explored this question using a sequential game-theoretic framework that emphasizes the central role of buyer uncertainty with respect to final consumer demand in a retailing supply chain setting. We found circumstances where both information sharing and information withholding might take place depending on the degree of initial uncertainty about market demand. But our most interesting result involves the recognition that a buyer that finds information withholding to be efficient initially may find itself locked into an less efficient outcome in the long run, as the upstream firms along the supply chain are able to infer the downstream firm’s sensitive information. This signaling mechanism becomes operative through orders that a buyer places with the supplier. It permits the supplier to infer information about final demand that the buyer is likely to face, permitting the supplier to potentially engage in profit-maximizing strategic behavior. Our results are consistent with some of the findings in prior research (especially Radharkrishnan and Srinidhi, 2003, and Cachon and Fisher, 2000), and retains the general theoretical perspective that information sharing will only be implemented by supply chain partner when the buyer and supplier are no worse off by exchanging information.

We also developed a basis for why the observed information sharing regime selections may be path-dependent. Our interpretation of how the buyer’s decision about which regime to adopt comes about is predicated on the idea that adoption is not forced (Cachon and Lariviere, 2001) and that information is shared without player dishonesty or inaccuracies (Brown, 1999). Thus, by withholding all shared information except procurement orders, the supplier is truly unable to know more than the buyer’s ordering signals communicate about consumer demand.
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2000, 83-96.


