

**Sharing Logistics Information Across
Organizations: Technology, Competition and
Contracting**

by

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SHARING LOGISTICS INFORMATION ACROSS ORGANIZATIONS: TECHNOLOGY, COMPETITION AND CONTRACTING

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Information technology has altered the way companies manage their supply chains, and has resulted in a variety of new inter-organizational logistics management approaches. Many partners who are adjacent on the supply chain can both gain from sharing information that was previously accessible to only one of them; this situation is typical in retailer-supplier interactions. Our study analyzes these different kinds of virtually integrated corporations — independent companies which operate somewhat like a single vertically integrated firm — and classify them based on the impact that the information shared has on the contracting parties. We find that there are four primary levels at which firms can share information. We then investigate how competition and contracting affect the nature of value sharing at each of these levels. Our results indicate that retailers and other buyers can successfully contract to end up with more value than is generated by the sharing of information, and that if the possibility of information sharing exists, then suppliers will end up worse off than before. Using game-theoretic models of strategic interaction, we show that this effect intensifies as the competitive value of the information to the supplier increases — paradoxically, as the value generated by a supplier from information sharing increases, the supplier loses more and more value. Furthermore, we demonstrate that in order to extract the competitive value of information from a supplier, the buyer need not actually share the information; the possibility of sharing is sufficient, even when the buyer cannot create value from that information. We also analyze the effects of other factors such as technology costs and demand uncertainty on these information sharing contracts. Finally, we show that the a critical predictor of the level of information sharing between companies is their relative positions on the supply chain, and that the drivers of the level chosen are relative bargaining power and potential agency costs.

Forthcoming in C.K.Kemerer, Ed., *Future Markets: How Information Technology Shapes Competition*. Kluwer Academic Press, 1997.

1. Introduction

The information revolution has dramatically altered the way companies manage their supply chains, and has spawned a variety of new inter-organizational logistics management approaches. Tremendous cost and delay reductions from information sharing, and the ability to use advanced information technology to exploit superior expertise outside the boundaries of the firm have resulted in a number of virtually integrated corporations — independent companies which operate somewhat like a single vertically integrated firm. A common form of virtual integration results from sharing logistics information across organizations. This inter-organizational form is a consequence of the fact that many partners who are adjacent on the supply chain can both gain from sharing information that was previously accessible to only one of them. This kind of win-win situation is typical to many relationships between retailers and distributors. Traditionally, the buyer (retailer) has the option of using advanced information systems to collect and share portions of its inventory and point-of-sales data with a select group of suppliers. However, it is also becoming increasingly common for the supplier to lead the move towards interfacing electronically with its customers — this trend may not be strategically sound in many cases, as we will show.

We examine several such arrangements, and investigate how they affect competition and bargaining. We also note that the total value gained from such contracts is sensitive to a number of industry specific and technological factors. In addition, the extent of competition in the market can significantly influence the nature of contracting and value sharing.

When information is shared, an important strategic issue is the level of information sharing. If sharing information generates value, one might argue, then why not share all relevant information available? Three observations are of consequence here. Firstly, the marginal returns from information sharing tend to be decreasing in the amount of information shared. Secondly, though the sharing of information adds value through improved operational efficiency, it also affects a different dimension of the buyer-supplier relationship: the relative bargaining power of the two parties. Thirdly, the nature of the information shared may affect the competitive position of the buyer or supplier with respect to their other industry rivals. These observations lead to a preliminary theory of information sharing across organizations, which is motivated in §2 and described in §3. The sources of value creation from sharing logistics information are detailed, with specific reference to four common forms of the virtually integrated buyer and supplier.

If one concludes that these arrangements are indeed value creating, then a natural question which arises is how they can be sustained; another is how the value generated is divided. For instance, a supplier may get tremendous performance improvements if permitted to access point-of-sales information; however, the buyer may not gain significantly from this arrangement. In a case like this, one would expect a contract of some kind to ensure that the information is shared on a

continuous basis, and that the value created is shared in a satisfactory manner. We examine such contracts in §4, and demonstrate that though the supplier actually creates more value, the commonly observed perception of the buyer-taking-all emerges when buyers and suppliers contract.

Another issue is that of control. There is a limit to the gains that one can achieve from sharing only information; more value can be added when decision rights and authority related to that information are also transferred from within the organization to an external business partner. Transferring the ownership of certain logistics related processes such as inventory management from one party to another is commonly observed in inter-organizational information sharing agreements. However, this introduces a problem similar to that studied in agency theory; since the two parties are business partners, and not a cohesive organization, they have different maximization objectives, and the shifting of decision making outside the organization can result in policies that may be optimal for the decision making party, but sub-optimal for the other party. In §5, we discuss how the position of the two parties on the supply chain is a critical determinant of the magnitude of these problems, and the ensuing arrangements that buyers and suppliers have. We also predict the typical agreements that firms adjacent on different parts of the supply chain will have.

A number of insights arise from our analysis. In §6, we conclude by briefly discussing these, along with what firm and product specific attributes are related to the value of shared information, and how they are likely to affect the different inter-organizational forms.

Existing work in the area of inter-organizational information sharing has covered a fairly wide range of topics. For instance, the impact of EDI on buyer-supplier relationships has been studied by Seidmann and Wang (1995) and Riggins and Mukhopadhyay (1994). Whang (1993) examines whether a seller should share lead time information with a customer. The ability to share information across organizations has created a move towards more transactions with fewer suppliers, and this is explained in part in Clemons, Reddi and Row (1993). The impact of IT on co-ordination across organizations, and bargaining power is studied by Bakos and Brynjolfsson (1993) and Clemons and Row (1993). In related work, Brynjolfsson (1994) uses the theory of incomplete contracts to study ownership of information assets within an organization.

2. The Nature of Information Sharing

At first glance, the diversity of the content of information, and the large number of sharing options makes it seemingly impossible to classify the nature or level of information sharing between companies. In order to get a better idea of how these sharing arrangements evolve, we have studied many examples of the typical forms

Case: OTC Products and the Electronic Age

ABC Corporation (the real name of the company has been withheld) started selling pharmaceutical over-the-counter (OTC) products in 1978. They have a variety of such products that they sell today. They rely heavily on electronic interfacing at various levels with their buyers in order to drive efficient supply chain management.

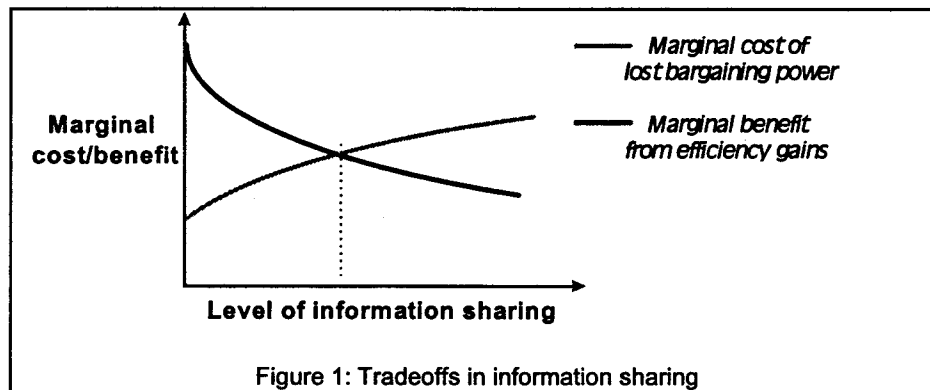
ABC was introduced to EDI in 1985. Their basic EDI process is fairly simple. Customers enter orders via EDI by sending UPC codes and order quantities to an electronic mailbox with a specific customer ID. Orders are retrieved four times a day, and after being screened for consistency, are translated and sent into ABC's order processing system. Currently, there are over 160 customers who use EDI for ordering. 70% of their dollar volume of orders comes in electronically, and 50% of the total number of orders use this system.

The benefits of the simple EDI system have been immense. Delivery times have been cut from an average of 21 days to an average of 5 days. Customer order problems, which would take 24 hours to handle, are resolved in less than an hour. The EDI system is handled by customer service representatives, who, instead of entering line items manually, now have more time to focus on advertising, selling and forecasting.

However, there are some concerns with this EDI system. Customers like to use the same UPC each time they order, and do not keep up with changing product types and packaging sizes; hence, a fraction of the orders tend to be for products that are no longer in existence. It is difficult to handle specialized product features, and promotional products, due to the information gap between the customer and ABC.

ABC has solved these problems and achieved further operating improvements using VMI. For instance, one of their retailers allows them to hook the EDI system into the retailer's inventory system. This allows them to view POS data — ABC controls the stock in the retailer's stores. This eliminates the information gap discussed earlier; it also allows ABC to generate superior demand forecasts. It has increased the number of inventory turns by over 300%. Another retailer does not allow this form of VMI, but gives ABC access to their POS information, to help marketing and sales. ABC also manages a whole category of OTC pharmaceutical products for one of their retailers.

The benefits could be many; however, ABC does not feel that the net value from these advanced supply chain management systems is tangible for them. They operate on stringent supply schedules, and bear a number of the ordering costs that the retailer used to have to bear. In short, though the efficiency of their logistics management has improved since they expanded beyond a simple EDI system, the retailer seems to have reaped all the benefits of the partnership.



of virtual integration. They have led us to recognize that a number of different information sharing arrangements are possible. For example, some suppliers share information related to the inventory position of the products a certain supplier sells them. This information may be transmitted daily, or weekly; the level of detail also varies. Another form of information that is exchanged commonly is payment information. There are suppliers who see the store-level day-to-day point-of-sales information; even with this form of information sharing, there is a great deal of variety in the information shared — some may see only product UPC's and quantities, while others have access to the distribution of sales over the day and the profiles of the customers who purchase their products. Other buyers transmit just order quantity and cost information using EDI - this is a situation where the volume of information exchanged may be great, but its impact on the other operations of the firm are relatively low. A quick reading of our case will illustrate the variety of such possibilities.

However, if one examines information from a different perspective, the problem simplifies a great deal. In §3, we treat the level of information shared not based on what its exact content is, but rather, based on the impact it has on the parties that contract to share the information. Using this view, one can classify the inter-organizational information sharing arrangements observed into four broad categories, based on the level of impact the shared information has on the buyer and supplier.

Before we detail these four categories, we first adopt a simpler approach — by considering homogeneous information. A simple model can explain why companies may not share all value adding information. Microeconomic theory has demonstrated numerous cases of diminishing marginal returns, and increasing marginal costs. Recognizing that the nature of costs and benefits in inter-organizational information sharing follow a similar pattern is the first step towards a clear understanding these arrangements. Consider the benefits of sharing information, and ignore, for the time being, the technology and infrastructure costs involved. When two adjacent firms on the supply chain first start sharing information, the erstwhile owner of the information (say, the buyer) will choose to share the information that (a) creates the

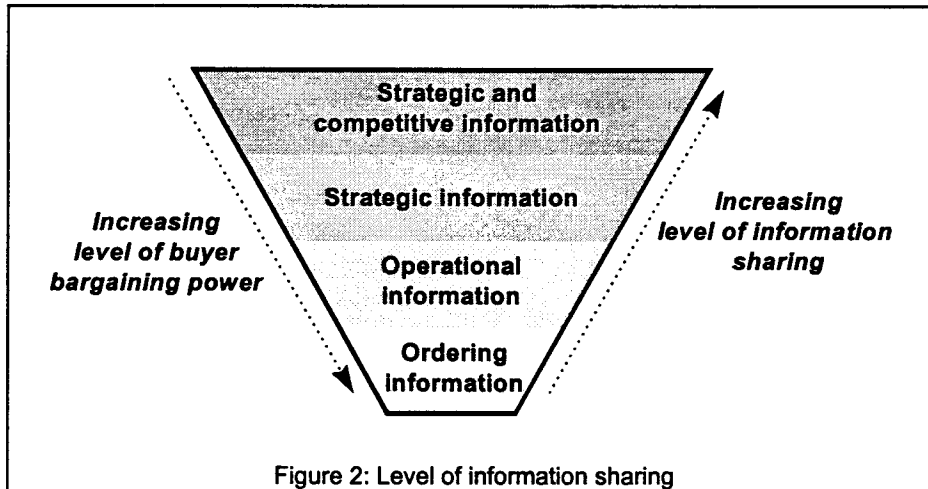


Figure 2: Level of information sharing

most value for the buyer and (b) that reduces the buyer's relative bargaining power the least. As the parties move towards sharing higher levels of information, the marginal value from sharing this information (i.e. the value per additional unit of information shared) will tend to reduce. Simultaneously, the relative effect that sharing this information has on its bargaining position will tend to increase, i.e. the marginal cost of sharing information will increase. At some point, the cost of sharing additional information will outweigh the benefits, and this is point at which the buyer will stop. This idea is illustrated in Figure 1.

This model may explain why firms share varying levels of information with different customers. For instance, the manufacturer mentioned in our case has different levels of electronic data interchange with different retailers and supermarket chains. WalMart is known to allow only certain vendors to manage their own inventories, while allowing other suppliers to view restricted sales data for their forecasting. Our first prescriptive result for retailers and other buyers is therefore simple: share information up to the point where it is beneficial for you to do so. However, how does one determine this point? The analysis in our subsequent sections will address this problem.

3. The Level of Information Sharing

We identify four different levels of information sharing between organizations (Figure 2). The first level involves superior exchange of transaction level information (like order quantities and prices) through EDI and related technology. The second level involves sharing select operational information (such as inventory levels) in order to exploit superior expertise across organizational boundaries, and

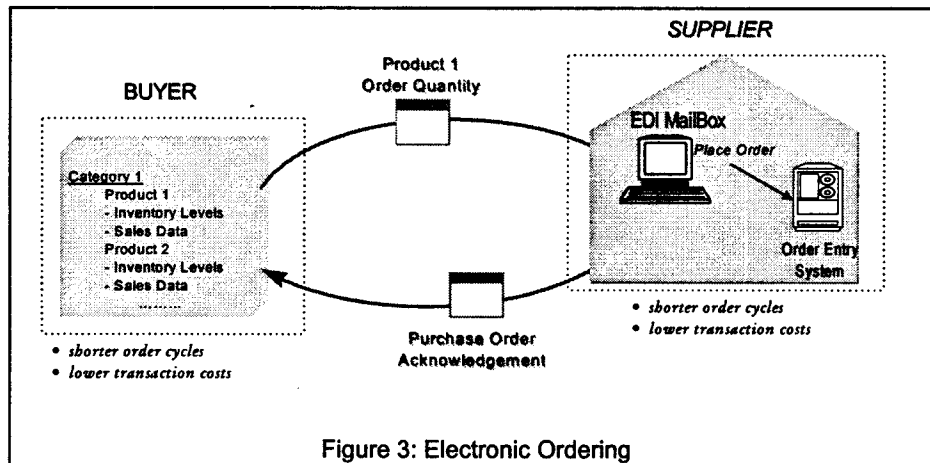


Figure 3: Electronic Ordering

possibly to further improve efficiency. At the third level, the information shared has strategic value to the party that receives the information. Finally, at the highest level, the information adds both strategic and competitive value to the party that receives it.

3.1 Exchanging order information

Since many inter-organizational logistics arrangements do not actually involve sharing firm-specific operations information, but merely improve logistics processes through efficiency gains from EDI, we treat that as our base case — the case where the companies exchange ordering information. (Figure 3) This is one of the oldest and most common forms of logistics management agreements between corporations, and is aimed at reducing transactions costs and the duration of order cycles.

At this level, there are few strategic issues involved in contracting; both parties gain from reduced order cycle times (which reduce inventory levels). The value gained is not joint; each party improves efficiency independently, and hence there are no value sharing issues. There is the issue, however, of information technology costs. One party may find it cost-effective to invest in an EDI system that enables these improvements; the other may not. However, both need to invest in the system in order to transact electronically. Prior studies have analyzed this situation (see, for instance, Seidmann and Wang, 1994) — subsidies are a common solution to this problem

3.2 Sharing operational information

In certain situations, information is shared to leverage on the superior expertise, or the operational economies of scale of one organization. This can occur in situations where one party owns valuable information, while the other party possesses the ability to use this information more efficiently. An example of this is vendor managed inventory (Figure 4). A buyer shares aggregate inventory position

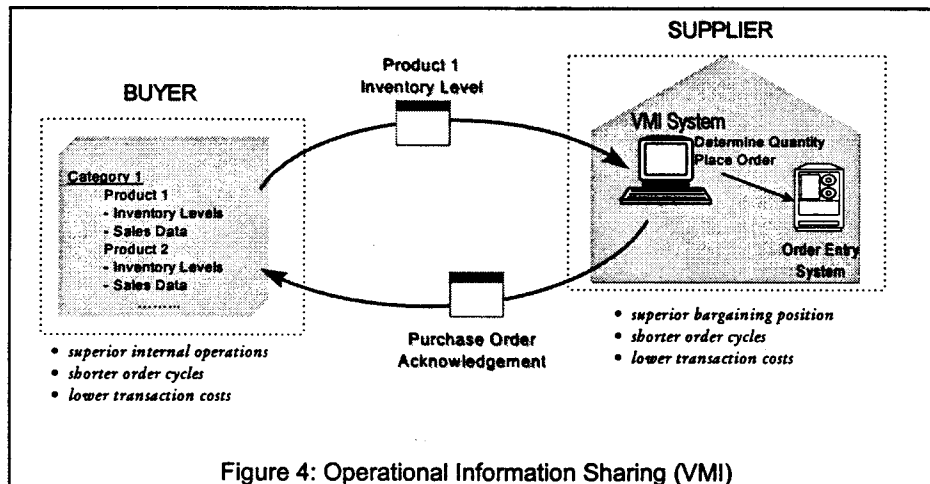


Figure 4: Operational Information Sharing (VMI)

information with its suppliers; this enables suppliers to manage the inventory of their own products at the buyer's site. If the supplier is better equipped to perform these duties, this may result in cost savings for both parties, since the supplier could have superior inventory management skills due to better organizational knowledge. There are other reasons why this could occur. Firstly, the supplier has experience managing large supply side inventories of this product. Secondly, the supplier has superior knowledge of the production schedule of the products in question. This knowledge reduces the supply-side uncertainty that a buyer normally faces, which will result in a lower average inventory for the buyer. Thirdly, if the supplier has comparable VMI arrangements with a number of suppliers, it can exploit operational economies of scale.

Inventory costs are not the only ones reduced. In the case of the pharmaceutical company we describe, when packaging specifications, product specifications or packaging quantities changed, an order sent for an old UPC would have to be returned and resent. When new products were introduced, there was a similar problem. Moving to VMI eliminated these difficulties. However, the buyer's costs of ordering and order fulfillment are now borne by the supplier, in other words, there are increased supplier-side costs.

What does the supplier intrinsically gain from all of this? The internal operating efficiency gains from an arrangement of this type are minimal at best. From the cases we have studied, the managers who run VMI systems feel that their benefits are intangible at best, and non-existent in the worst cases. However, one benefit that may not be immediately tangible (if it exists) is that the supplier's relative bargaining position for its other transactions with the buyer may improve. Since it has superior knowledge of how well or badly its product is doing on a regular basis, the information asymmetry it faces will be reduced; it may therefore be able to bargain for price schedules that are more in its favor.

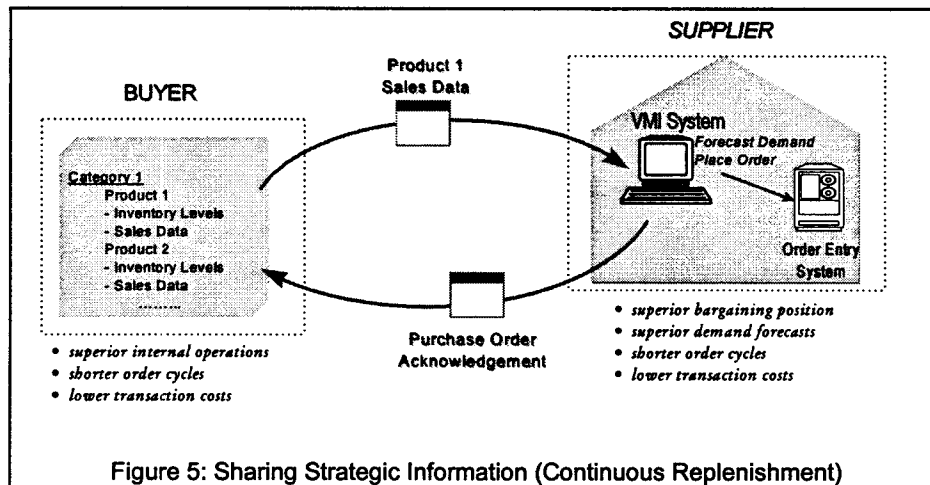


Figure 5: Sharing Strategic Information (Continuous Replenishment)

It is likely that the contracts underlying these sharing agreements will include value sharing agreement between the buyer and the supplier. Alternately, there could be a penalty for non-VMI suppliers. This penalty could range from a complete shut-out ('we do business only with suppliers who manage their own inventories in our stores' — implies a strong bargaining position on the buyer side) to some kind of price advantage that the buyer passes on to the supplier. Our discussion in §4 and the appendix provides insight into these issues.

3.3 Sharing strategic information

It is becoming increasingly common for organizations to share brand-specific information which provides strategic benefits to one of the organizations, and also leverages on the superior expertise of one of the organizations (Figure 5). This occurs when one organization possesses information that it can derive little independent value from, but which another organization can use to generate strategic benefits for itself, and operational benefits for the other company. For instance, a retailer may possess POS (point-of-sales) information on all the products it sells. This information is not of much value in isolation; however, a supplier can make superior demand forecasts by analyzing detailed transaction level POS information from many retailers. This approach is used extensively in the efficient customer response, continuous replenishment and quick response systems models.

Since inventory positions can easily be derived from POS information, the operational information that was the topic of §3.2 is also being shared. Hence, both the buyer and supplier benefit from the superior inventory management discussed earlier, and all the benefits that accompanied VMI-type situations are still present. However, the information the supplier has access to is of a much higher level of detail than mere inventory aggregates. The first implication of this is that this information can be used to improve the internal operating efficiency of the supplier through improved demand forecasting. The level of detail that is required for a

successful forecast is available in POS data, and hence more accurate aggregate forecasts are feasible. Also, the supplier can gain a good idea of sales patterns in different geographical regions, and across different seasons; in other words, it has the information to make segment-specific forecasts, which can be of significant value to its sales and product development groups. According to the director of worldwide sales forecasting at Eastman Kodak, such region specific and tactical demand forecasts are increasingly becoming a major role of sales forecasting (Chase, 1996) Since reduced demand uncertainty will improve the internal inventory management of the supplier, it may also gain from reduced operating costs.

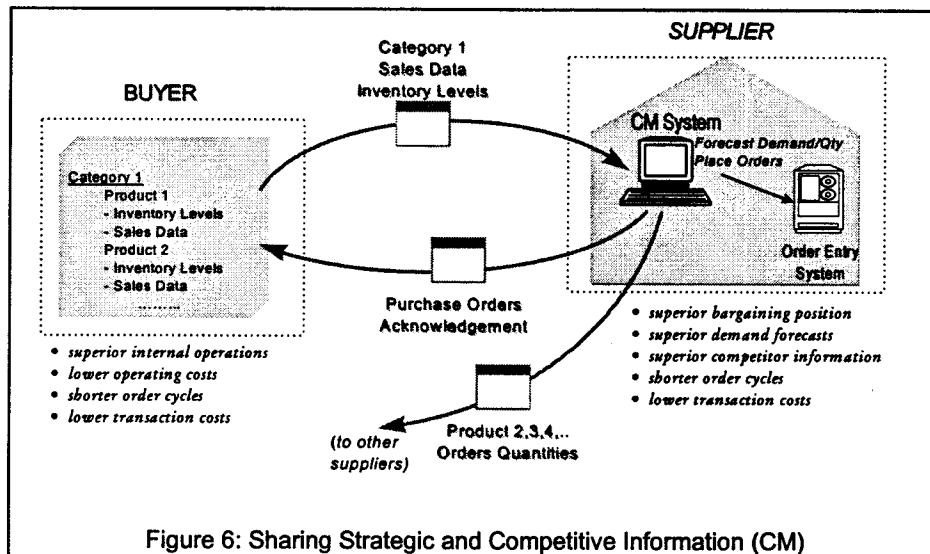
This form of information sharing is currently common in the grocery and fashion retailing industry, and the model has been discussed for many years now – supply chain management has always striven to move from a ‘push’ system towards a ‘pull’ system, where consumer purchases pull goods through the chain, rather than suppliers pushing them. However, its scope has been widening over the last couple of years, extending to industries as diverse as brewing and forestry. For instance, after capacity gains of 5% at no extra cost from an EDI system, Bass Brewers has recently started experimenting with a VMI system.

The benefits described above may indicate that the buyer can induce suppliers unwilling to enter into information sharing agreements described in §3.2 by offering them access to information that is of strategic value — on the face of it, the buyer does not seem to incur any additional cost, as the data is automatically generated in any case — there is no additional information processing overhead. The supplier and the buyer both seem to gain from this arrangement — the buyer gets improved operating efficiency and reduced transaction costs, and the supplier is able to generate forecasts using information that that it would otherwise not be able to obtain.

However, when this information is available to the supplier, the relative bargaining power of the buyer is further reduced. For instance, in the POS example above, the supplier now knows not only gross product movement figures, but also the details of what prices the buyer charges consumers, any local demand patterns and the schedule of promotions — this puts the buyer at a significant disadvantage when negotiating supply terms. Pre-specification of supply terms may alleviate this problem — however, this is only possible when the buyer and the supplier enter into a long term contract. Unfortunately, this is not very practical when the rate of new product development is high — typically, however, one sees continuous replenishment dominantly in industries of this kind.

3.4 Sharing strategic and competitive information

At the highest level of information sharing, it is possible for a buyer to allow a supplier to access broad market information that provides strategic and competitive benefits to one of the organizations, apart from leveraging on the superior expertise of that organization. Again, this occurs when one organization possesses information



that it can derive little independent value from. However, the other organization can derive internal strategic benefits as well as competitive benefits from this information. The competitive benefits are with respect to intra-industry rivals — this information does not give the supplier additional competitive advantage over the buyer, but over other suppliers in its own industry. Category management is an example of this situation (Figure 6). In general, one buyer (the retailer) deals with many competing suppliers in a particular category. Therefore, endowing one of the suppliers with inventory management responsibility over all the products supplied for that category, and providing them with the relevant POS information gives that supplier strategic benefits (from improved demand forecasts), competitive benefits (from sales and demand information about competitor's products), and will enable superior inventory management. It also reduces the buyer's operating costs tremendously — not only are all order management costs eliminated, but the buyer deals with only one supplier per category, and hence has a significant reduction in information technology costs.

On the face of it, the supplier appears to gain tremendously when provided access to this information. Not only are demand forecasts superior through POS information about the supplier's own products, but category forecasts can be made much more accurately. The supplier can track the sales of competing products, and use this information to improve the sales strategy of their own product. Since there may be an additional time lag between the category manager generating an order, and a competing supplier receiving it, inventory costs of competing products will tend to be higher, and hence the category manager may gain a cost advantage as well by enabling the buyer to price their product lower. The tradeoff appears to be increased transaction costs for the supplier, who manages, orders and monitors product movements of a whole category of products.

In this section, we have discussed the sources of value creation when two companies share information at different levels. In §4, we examine how this value will be shared by the two firms.

4. Information Sharing Contracts

We define the value generated by an information sharing arrangement as the total additional dollar amount that the buyer and the supplier gain as a result of the agreement. For instance, if the firms transact electronically using EDI, the value generated is the sum of the dollar amount of cost savings that accrues to the supplier (from reduced processing costs) and the dollar amount of cost savings that accrues to the buyer, due to reduced inventories and quicker turnaround.

We consider three levels of information sharing — electronic transactions, strategic information, and strategic and competitive information — since the most interesting contracting situations arise in these cases. In a general buyer-supplier framework, these correspond to the examples of EDI, VMI with POS data sharing, and category management. The nature of value sharing is determined by the contract that the two parties enter into. The first point of significance is that prior to any sharing agreement, the buyer is the owner of the information, and will therefore tend to have a bargaining advantage during the negotiation process. However, this by itself does not insure that all the value will accrue to the buyer, as the supplier is responsible for generating value from that information and can potentially use this fact to negotiate for a larger share.

In simple EDI contracts, there is not much flexibility on the part of either party (the buyer or the supplier): the value created is simply due to a reduction in administrative costs on both sides, and there is very little room for the buyer to maneuver by playing one supplier against another, or withholding information for better contracting terms (since there is no actual exchange of internal information like inventory levels or POS data). In these situations, the decision to contract, and the ensuing value sharing is likely to be simple (each party keeps their own gains; if one makes a loss due to high technology costs, the other may subsidize EDI adoption to enable some value creation). The more interesting and complex situations are when internal information is transferred (i.e., VMI with POS information sharing, category management). To illustrate some of these issues, we construct a simple example. Readers who wish to skip the details may proceed directly to the following discussion of contracting issues.

Example: There is one buyer (B), and two competing suppliers (S1 and S2), both of whom are large enough players in the market to assume the role of category manager. Currently, the buyer transacts with both suppliers individually using an EDI link (electronic transactions). The buyer can choose to enter into a VMI (with POS data sharing) arrangement with one or both suppliers. or a category management arrangement with one supplier. The sources of value creation are

assumed to be inventory gains for the buyer (termed i) and strategic and competitive gains for the supplier (termed sc - from better forecasts, information about the competing supplier's sales). There may also be an implicit transfer of bargaining advantage from the buyer to one or more of the suppliers (termed b). v represents the net value to each of the parties ($i+b$ in the case of the buyer, and $sc+b$ in the case of suppliers)

Assume that in a particular situation, the value creation from different sharing arrangements per time period are as follows (all numbers are in millions of dollars). The 'Total Value' is the value gained by the *contracting parties*.

Table 1: Value created by different sharing arrangements

Sharing Arrangement	Buyer			Supplier 1			Supplier 2			Total Value
	i	b	v	sc	b	v	sc	b	v	
VMI (B-S1)	1	-0.5	0.5	2	0.5	2.5	-	-	-	3
VMI (B-S2)	1	-0.5	0.5	-	-	-	2	0.5	2.5	3
VMI (B-S1 and B-S2)	2	-1	1	1	0.5	1.5	1	0.5	1.5	4
S1 as category manager	1	-0.5	0.5	3	0.5	3.5	-1	-	-1	4
S2 as category manager	1	-0.5	0.5	-1	-	-1	3	0.5	3.5	4

Whenever the buyer shares POS data with a supplier, the buyer suffers a loss of \$0.5 million due to a shift in bargaining power - the supplier gains this. The supplier also gains strategically from better forecasts - this gain is lower if both the suppliers see their respective POS information (in which case, if there is any form of competition, part of the gain is competed away - in this simple numerical example, the gain is assumed to be halved) If either of the suppliers becomes a category manager, they gain *all* the strategic advantage of VMI (a gain of 2 million), plus an additional competitive gain (a gain of \$0.5 million, which the other supplier loses). The buyer, however, loses some inventory savings, as only one supplier is managing their own inventory (the other takes orders from the category manager via EDI).

On the face of it, it appears that the buyer will choose to enter into VMI arrangements with both suppliers, as its gain is the most — the suppliers seem to get the bulk of the benefits, though. However, consider the following contract:

(C1) A long term VMI contract in which the supplier *pays* the buyer \$2 million per period

We contend that the buyer can induce each supplier to accept this contract, by threatening to offer a category management contract to the other supplier. Specifically, suppose the buyer offers the following sequence of contracts:

Stage 1: The buyer offers both suppliers contract (C1)

Stage 2: If both accept the contract, then the issue is settled. If one or both of them do not accept the contract, then the buyer does the following.

If one of them has accepted, the buyer offers that supplier a category management contract for an additional payment of \$0.9 million from the supplier to the buyer. If neither of them has accepted, the buyer randomly offers one of them a category management contract for a payment of \$2.9 million from the supplier to the buyer (randomly would imply that there is a 50% chance of either of them getting offered the contract)

To understand why both will accept the VMI contracts in this case, let us start by examining the second stage, *if it is reached at all*. There are three possible scenarios:

1. Only Supplier 1 could have accepted the VMI contract.
2. Only Supplier 2 could have accepted the VMI contract.
3. Both of them could have refused the contract.

Table 2 below shows the position of the firms in each of these three scenarios after the first stage (again, all amounts are in millions of dollars). Now, in each situation, one of the suppliers is offered category management for a payment of \$2.9 million from the supplier to the buyer. The choices (Case 1 through Case 3), and resulting net profits to each firm in each of these cases is analyzed in the following paragraphs.

Table 2: Firm position after stage 1

Sharing Arrangement	Buyer			Supplier 1			Supplier 2			Total Value
	v	p	net	v	p	net	v	p	net	
1. VMI (B - S1)	0.5	2	2.5	2.5	-2	0.5	0	0	0	3
2. VMI (B - S2)	0.5	2	2.5	0	0	0	2.5	-2	0.5	3
3. No VMI	0	0	0	0	0	0	0	0	0	0

Case 1: Supplier 1 has accepted the VMI contract and is now offered the CM contract

Table 3: Payoffs after stage 2 in Case 1

Sharing Arrangement	Buyer			Supplier 1			Supplier 2			Total Value
	v	p	net	v	p	net	v	p	net	
1A. Supplier 1 refuses CM, sticks with VMI	0.5	2	2.5	2.5	-2	0.5	0	0	0	3
1B. Supplier 1 accepts CM	0.5	2.9	3.4	3.5	-2.9	0.6	-1	0	-1	4

The buyer gains by offering the CM contract, and supplier 1 gains by accepting it. Hence, supplier 1 will accept, and the final profit to the suppliers will be \$0.6 million to supplier 1 and *negative* \$1million (a loss) for supplier 2

Case 2: Supplier 2 has accepted the VMI contract and is now offered the CM contract

Table 4: Payoffs after stage 2 in Case 2

Sharing Arrangement	Buyer			Supplier 1			Supplier 2			Total Value
	v	p	net	v	p	net	v	p	net	
1A. Supplier 2 refuses the CM, sticks with VMI	0.5	2	2.5	0	0	0	2.5	-2	0.5	3
1B. Supplier 2 accepts CM	0.5	2.9	3.4	-1	0	-1	3.5	-2.9	0.6	4

The buyer gains by offering the CM contract, and supplier 2 gains by accepting it. Hence, supplier 2 will accept, and the profit to the suppliers will be \$0.6 million to supplier 2 and *negative* \$1million (a loss) for supplier 1

Case 3: Neither have accepted, and the buyer randomly offers a CM contract to one of the suppliers for a payment of \$2.9 million

The buyer gains by offering the CM contract, and either supplier gains by accepting it if offered (since it raises that supplier's profit from 0 to \$0.6 million). Therefore, whoever is randomly offered the CM contract will accept it. However, there is a 50% chance that each supplier is offered it. Therefore, if case 3 occurs, each supplier has a 50% chance of getting \$0.6 million, and a 50% chance of suffering a *loss* of \$1 million Hence, the expected profit to each is $0.5 \cdot -1 + 0.5 \cdot 0.6 = -0.2$ (a loss of \$0.2 million). Therefore, if case 3 occurs, the expected loss of both suppliers is \$0.2 million. The payoffs are summarized in Table 5.

Table 5: Payoffs after stage 2 in Case 3

Sharing Arrangement	Buyer			Supplier 1			Supplier 2			Total Value
	v	p	net	v	p	net	v	p	net	
3A. Supplier 1 offered CM, accepts it	0.5	2.9	3.4	3.5	-2.9	0.6	-1	0	-1	4
3B. Supplier 1 offered CM, refuses it	0	0	0	0	0	0	0	0	0	0
3C. Supplier 2 offered CM, accepts it	0.5	2.9	3.4	-1	0	-1	3.5	-2.9	0.6	4
3D. Supplier 2 offered CM, refuses it	0	0	0	0	0	0	0	0	0	0

Now let us consider the fourth possibility (both accept, and there is no second stage). In this case, both suppliers have a net loss of \$0.5 million (a benefit of 1.5 less a payment of 2). Having analyzed the second stage as well, we know the *final expected payoff* for all of the cases of first stage actions. These are summarized in Table 6 below. The first figure in parenthesis represents supplier 1's profit, and the second figure represents supplier 2's final profits. A negative number implies a loss. As one can see, the game reduces to the familiar *prisoner's dilemma* game. The dominant move for both the suppliers is to accept the VMI contract. For instance, consider supplier 1's options. If supplier 2 accepts, it is better for supplier 1 to accept (payoff of -0.5 vs. payoff of -1). If supplier 2 refuses, it is still better for supplier 1 to accept (payoff of 0.6 Vs expected payoff of -0.2). Hence, given the threat of the second stage contract, it is dominantly optimal for both suppliers to accept the VMI contract.

Table 6: Final payoffs for each set of stage 1 actions

Stage 1 Actions	Supplier 2 accepts VMI contract	Supplier 2 refuses VMI contract
Supplier 1 accepts VMI contract	(-0.5, -0.5)	(0.6, -1)
Supplier 1 refuses VMI contract	(-1, 0.6)	(-0.2, -0.2)

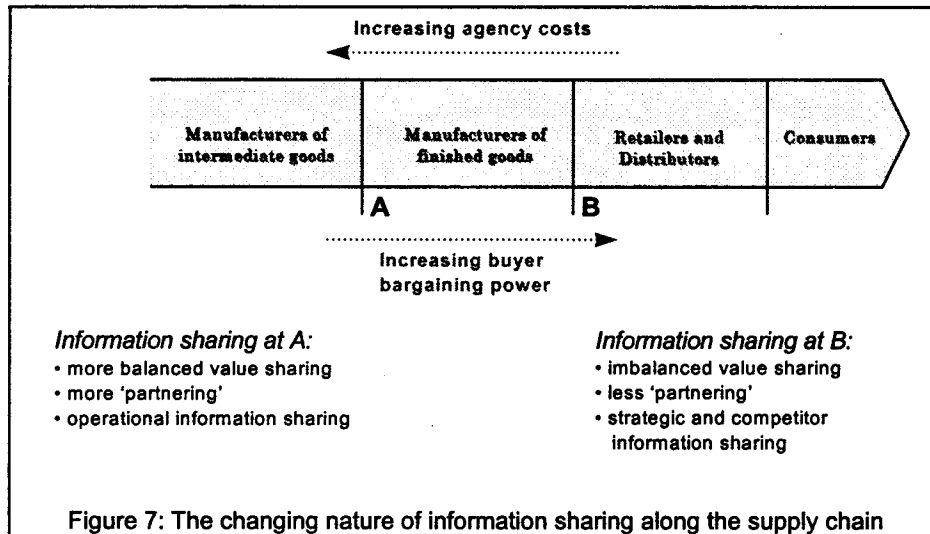
This example shows how the threat of losses from competition can result in the retailer extracting not only all the value from VMI, but actually making the suppliers worse off than they would be with *no* form of information sharing. Suppliers always feel that there are no tangible gains from VMI or category management; this example shows why. We outline a generalization of this example in the appendix.

A salient result that emerges is that suppliers may agree to VMI contracts that are unfavorable, as this eliminates the threat of an even more unfavorable situation

where another supplier gets a category management contract. The buyer is the clear winner here — note that it is possible for the buyer to actually gain more than the total value created, by extracting additional surplus from the supplier. This also implies that when a supplier enters a position where the buyer can offer category management to more than one person, the resulting outcome will make the suppliers worse off than they were. This may act as a deterrent to suppliers entering into information sharing agreements at all — since one supplier entering will ensure that the other also does, and will set the buyer up to extract all value from the arrangement. Therefore, in markets where there are no dominant suppliers, one expects to have seen suppliers pushing for favorable long-term contracts when entering into information sharing agreements — this would have been in order to prevent subsequent opportunistic behavior by the buyer. It is likely, however, that vendors did not foresee the possibility of category management when they entered into VMI agreements — hence, in the current situation, the buyer has all the advantage.

One might argue that it is unlikely that the suppliers actually pay buyers in practice. This is true, and is possibly a contracting problem for the buyer (existing arrangements may not allow actual dollar payments from the supplier to the buyer). However, the payment need not be a dollar amount; it could involve the supplier taking on inventory management costs and ordering costs from the buyer, equivalent to a comparable payment. One sees administrative costs rise for the supplier when VMI and category management agreements are entered into. The supplier tends to view this as a consequence of the ‘buyer having all the power’. This vague feeling of suppliers that they ‘have no say’, and that they bear all the costs that should be shared can be precisely explained by the contracting issues discussed above. The supplier pays the buyer by taking on these costs; though the costs may exceed the benefits the supplier accrues from having access to the information, this is not irrational — it is a rational move by the suppliers to prevent a real threat of an even more unfavorable situation.

When there is one dominant supplier in a category, the situation changes. This supplier is the most favorable candidate for a category manager, as inventory savings for the buyer from having this supplier manage their own inventory are high. Also, inventory gains for the dominant supplier from a VMI agreement are high. Therefore, the total value generated by having a dominant supplier as the category manager are bound to be the most. However, the competitive losses to the dominant supplier if a smaller supplier becomes the category manager are significant — it may enable the small supplier to erode the market share of the bigger supplier significantly. Therefore, the threat of imposing competitive losses on the dominant buyer by making a smaller supplier the category manager can ensure that the buyer enters into a CM agreement, but extracts a lot of the value. In order to make the threat credible, the buyer will probably yield a little more value to the dominant supplier — however, one can construct an illustrative example where it will be clear that a large portion of the gains go to the buyer. This is again observed in practice — even dominant suppliers find that the buyer wins most in category management,



despite the fact that they are generating the value, and there is no competitor of comparable size who could take on their role.

A more formal treatment of some of these issues are outlined in Appendix A. There are a variety of interesting insights one can infer; the main insights from this analysis, and the discussion above are summarized in §6.

5. Position on the Supply Chain

Having explored the competitive and contracting issues that determine value sharing when information is exchanged between a buyer and a supplier, we now turn our attention to the position of the buyer and supplier on the supply chain. At first glance, this may not seem like a significant factor, in light of the model discussed in §4. However, it does tend to influence some of the parameters of the contracting environment, and can introduce other valid concerns. The discussion will be brief, and will focus on two salient features: bargaining power and agency costs. We consider two interfaces on the supply chain. In the first case, the supplier supplies intermediate goods/parts, and the buyer is a manufacturer who converts them into finished goods. This is position A in Figure 7. In the second case, the supplier is a manufacturer of finished goods, and the buyer is a retailer or a distributor who simply resells the finished product. This is position B in Figure 7.

As one moves from point A to point B, two key observations can be made:

The relative bargaining power of the buyer increases. When a manufacturer contracts with a supplier of parts or intermediate goods, the supplier has a relatively good bargaining position. This is because in many cases, substitutes are not readily

available to the buyer — there may not be an open competitive market for these parts, or the parts may be customized to suit the buyer's manufacturing needs. This is a commonly observed situation in the automotive industry. On the other hand, when a finished goods manufacturer supplies a retailer, the retailer has readily available substitutes in most cases, and therefore is not really dependent on any one supplier for their profits. Another driver of this phenomenon is the difference in value addition in each case. A manufacturer adds a lot more value to intermediate parts than a retailer does to finished goods; hence the manufacturer has a lot more at stake in terms of profits with any given supplier than a retailer does.

The agency costs that the buyer faces reduce. When a supplier of parts supplies a manufacturer, there is a much higher risk of costly holdup that could arise from a missed order delivery, or insufficient inventory on the buyer's (manufacturer's) side. A supply schedule that is independently profit maximizing for the supplier may adversely affect the production schedule of the manufacturer; hence, transferring management authority or decision rights about inventory positions or supply schedules to a supplier is potentially expensive. However, a supplier of finished goods has profit maximizing incentives that are naturally aligned to a large extent with the retailer. Both of them want to sell as many finished goods as possible to the consumer — an optimal supply schedule for the manufacturer tends to be close to optimal for the buyer (retailer). Complementarities between different input factors is another reason for this difference in agency costs. The value of a set of intermediate goods to a manufacturer is much higher than the sum of their individual values (a car door in isolation is not worth much unless combined with the other parts of the car). Hence, the potential holdup costs one supplier can impose on the buyer are much higher in this case. On the other hand, if a retailer does not get a desired shipment of soap, it does not significantly affect the value of any other related products — sales are individual, and apart from minor scale effects (people shop at bigger stores as they get lots of products there), the costs a supplier imposes on the retailer's profits from other products when acting sub-optimally on one product are negligible.

Based on these two observations, one can draw some conclusions about the form of information sharing agreements between buyers and suppliers across these two different interfaces of the supply chain.

Conclusion 1. At point A, one expects to see no more than operational information sharing; at point B, one expects to see strategic and competitive information sharing. This is due to the lowered agency costs faced by the buyer as one moves closer to the consumer. Since the manufacturer is much more dependent on the supplier, there will be a reluctance to transfer decision rights across firm boundaries; there will be a lot of mutual information sharing and decision making. Manufacturers may share some inventory information with suppliers; however, the nature of their agreement will tend to be either a very closely monitored VMI, or simply electronic transactions, with shared inventory information to allow the supplier to plan their schedules better. Competitive information sharing arrangements with suppliers are unlikely, as this magnifies the agency costs the buyer could bear due to any

particular supplier. This also partly due to the complementarities between supplied parts discussed earlier. Retailers, on the other hand, will definitely enter into extensive information sharing and decision rights transfers with their suppliers; category management is fairly common, and will continue to be — to prevent opportunistic behavior by the supplier such as holdup of competitor's products, simple minimum-quantity contracts are used (again, since the buyer has the ability to extract all value from these arrangements, the suppliers will tend to comply with such demands). VMI will also continue to be common. In some cases, buyers may avoid moving to category management arrangements; VMI arrangements may be more value adding, as described in §4. The natural alignment of decision rights across the firm boundary is an important factor here — retailers have little to gain from working in conjunction with their suppliers, (as opposed to 'hiring' them) so there will be a transfer of decision rights across boundaries fairly easily. There is the implicit knowledge that when a manufacturer makes a supply decision that is sub-optimal for the supplier, it affects the manufacturer adversely as well.

Conclusion 2. As one moves towards point B, the buyer extracts a much larger portion of value created. This is due to the increased bargaining power of the buyer. Since a retailer is likely to have competing suppliers on a continuous basis, there is a lot more scope for value extraction by pitting the suppliers against one another. It is also a consequence of observation 1; the rational feasibility of a larger set of potential information sharing arrangements with suppliers enables the buyer to rationally threaten suppliers and get favorable contract terms. Recall in the example of §4, it was not even necessary for the buyer to enter into a category management contract; the existence of the possibility was sufficient to get all the value create (and more) from the suppliers (this could be a different interpretation of what a 'pull' system along the supply chain means). At point A, there is little flexibility in terms of rational agreements, and there is also a less competitive supplier pool.

Conclusion 3. As one moves from point B towards point A, the level of partnering between buyer and supplier will increase. This is a consequence of observations 1 and 2, and also partly due to the reduction in bargaining advantage. At point B, a retailer has no real need to partner with a supplier; mutual monitoring is unnecessary, and the gains to the retailer through a competitive contract are much higher than, say, a Nash bargaining outcome. Also, the retailer adds little value to the products it buys and sells; hence a higher level of product specific information or production schedules is not of consequence in this regard. At point A, however, since supplier monitoring by the buyer is essential, partnering is a likely outcome. There is little chance that the manufacturer can extract significant value from the supplier through a competitive contract, and hence an arrangement where the market plays less of a role is advantageous. Since the manufacturer adds a great deal of value to the parts it buys from a supplier, a better knowledge of the suppliers production schedules, and product-specific information is of high value to the manufacturer; partnering will help in this regard as well.

We conclude with a discussion of our salient insights, along with a brief description of other product and technology specific factors that may be of relevance.

6. Summary and Insights

Corporations have long been aware of how information systems can allow them to operate across organizational boundaries; however, there has not been much research into the competitive implications of these inter-organizational information systems. There has also been significant concern on the part of suppliers who see no tangible benefits accruing to them from different information sharing arrangements which they continue to be a part of. Our study offers the following insights into these long-standing concerns.

1. The impact of inter-organizational information sharing (IOIS) is not merely operational; it alters and shapes competition in supplier markets.
2. It is feasible for a buyer to extract all the competitive value of information from each supplier. Therefore, it is worthwhile for buyers to collect as much information as possible that is of competitive value to their suppliers — they need not actually share it to reap its value — a realistic threat of potential sharing is sufficient
3. In a supplier market with many competing suppliers of the similar size, VMI contracts are likely to be the most favorable outcome for a buyer; though category management may offer higher operational savings, a buyer can do better by extracting competitive value from the suppliers with the threat of CM.
4. The following factors are likely to increase the operational savings that a supplier expects from a through IOIS:
 - High inventory cost rates (which could be lowered through VMI)
 - High demand uncertainty (which could be improved through better demand forecasts based on POS data)

These factors can certainly increase the value of IOIS. However, the supplier should examine the competitive factors involved in these arrangements, before being tempted by large (and sometimes illusory) cost savings, as the buyer could end up getting all the value from the arrangements.

5. Buyers should target suppliers who have the characteristics described in (IV) with IOIS arrangements, as they are likely to be tempted by the prospect of high operational savings — since these savings are likely to accrue to the buyer, these are better firms to share information with. The same holds for highly competitive supplier markets. Partnering with suppliers (as advocated by many supply chain management information systems vendors) is rarely optimal for the buyer. There is little reason for buyers to be worried about loss in

bargaining power when they share information; through creative contracting and competitive threats, they can regain any power they might apparently lose.

6. If a supplier is in a inter-organizational information sharing agreement, it is unlikely that she can capture any of the value generated; however, it may still be necessary to remain in the agreement, to avoid further losses. If you are a supplier, and you break even on a VMI or category management agreement, you are probably doing better than you should.
7. As information technology enables buyers to use and share their information more effectively, they are bound to be able to 'pull' more and more from suppliers. Hence, suppliers may do well to negotiate long-term VMI contracts with buyers. Even if these contracts generate little or no apparent present or future value, they are insurance against what will only become a less favorable market for them. This is particularly true in highly competitive markets; if a buyer possesses competitive information that is potentially very valuable to a supplier, this is not a sign of one supplier benefiting a lot, but rather a predictor of all suppliers losing a lot.
8. As the cost of processing and sharing information drops (as is evidently has and will continue to do), two related occurrences are very likely:
 - The volume of information that a buyer collects (and can potentially share) will increase
 - The strategic and competitive value of this information to suppliers will increase
9. In the light of our analysis, this spells more profits for the buyer, and more value extraction from suppliers.
10. Firms further away from the consumer on the supply chain will do well to partner with their suppliers. A good example of such a case is that of Chrysler. It is unlikely that these firms can extract value from their suppliers the way retailers do; the potential agency costs of such competitive information sharing will most likely outweigh the benefits

Our ongoing studies are aimed at precisely modeling the effect of technology and competition on contracting in a heterogeneous supplier market. We are also investigating the issue of asymmetric information about the value of the information, and the potential incompleteness that the contracts over information shared could have.

Appendix: Preliminary analysis of contracting issues

Consider a situation with one buyer (B) and two competing suppliers (S1 and S2). Each supplier i manufactures one product, called product i . We examine three situations — no information sharing, VMI with POS data transfer, and category management. When there is no exchange of information, the net benefit to all parties

is zero. We model the value of information sharing between organizations as being generated by two primary factors:

1. **Inventory and other operational savings for buyer:** If the buyer shares demand information (POS) about product i with supplier i then this results in cost savings of i_i for the buyer.
2. **Strategic revenue for the supplier:** If supplier i has *exclusive* access to demand information about product i , then the supplier gains an amount s_i . If both suppliers have access to their respective demand information, they both gain αs_i . α is an indicator of the competitive environment.
3. **Competitive revenue for the suppliers:** If supplier i has access to both its own demand information, and to that of supplier j , then supplier i gets a competitive gain of c_i , and supplier j loses an equal amount. Strictly, this is not value creation, as it is a zero sum situation; however, if B and S_i contract, they are jointly better off by this amount in some situations (even though S_j may lose this amount, it is still extra value for B and S_i)

In addition, there are the following transfers, depending on the information exchanged:

- A. **Bargaining power transfers:** If supplier i has access to their own demand information, then the buyer loses b_i – this reflects a potential loss in bargaining power. Supplier i gains this amount b_i .
- B. **Contractual payments:** When B contracts with S_i , there is a transfer payment of p_i from S_i to B. This could be a dollar payment, or a reflection of one of the parties bearing administrative costs that the other used to bear. p_i can be negative.

Given our assumptions, there are six possible situations: VMI between B and S_1 , VMI between B and S_2 , VMI with both S_1 and S_2 , S_1 as category manager, S_2 as category manager, and no information exchange. The costs and benefits to each party under each arrangement, along with the net value created by the arrangement are summarized in Table A1.

We start by assuming that the suppliers are identical, i.e. $i_1 = i_2 = i$, $c_1 = c_2 = c$ and so on. First, we examine the case in which the buyer wishes to make one of the supplier a category manager. The value that is generated from this arrangement is $s+i+c$. In the absence of competition for either the buyer or the supplier, one would expect them to share this value (that is the predicted Nash bargaining outcome), which can be achieved through a payment of $p = b + 0.5(s+c-i)$ from the supplier to the buyer. However, the buyer has two competing suppliers; and hence can extract more value from the supplier through the contract. Let us assume that the payment agreed upon is p_{CI} . The following result is immediately clear:

Lemma 1: $p_{CI} < b + s + 2c$

Table A1: Payoffs under different sharing arrangements

Sharing Arrangement	Buyer			Supplier 1			Supplier 2			Total Value
	v	p	net	v	p	net	v	p	net	
	None	0	0	0	0	0	0	0	0	
VMI (B - S1)	$i_1 - b_1$	p_1	$i_1 - b_1 + p_1$	$b_1 + s_1$	$-p_1$	$b_1 + s_1 - p_1$	0	0	0	$s_1 + i_1$
VMI (B - S2)	$i_2 - b_2$	p_2	$i_2 - b_2 + p_2$	0	0	0	$b_2 + s_2$	$-p_2$	$b_2 + s_2 - p_2$	$s_2 + i_2$
VMI (B - S1 and B - S2)	$i_1 + i_2 - b_1 - b_2$	$p_1 + p_2$	$i_1 + i_2 - b_1 - b_2 + p_1 + p_2$	$\alpha s_1 + b_1$	$-p_1$	$\alpha s_1 + b_1 - p_1$	$b_2 + \alpha s_2$	$-p_2$	$b_2 + \alpha s_2 - p_2$	$i_1 + i_2 + \alpha(s_1 + s_2)$
S1 as category manager	$i_1 - b_1$	p_1	$i_1 - b_1 + p_1$	$b_1 + s_1 + c_1$	$-p_1$	$b_1 + s_1 + c_1 - p_1$	$-c_1$	0	$-c_1$	$s_1 + i_1 + c_1$
S2 as category manager	$i_2 - b_2$	p_2	$i_2 - b_2 + p_2$	$-c_2$	0	$-c_2$	$b_2 + s_2 + c_2$	$-p_2$	$b_2 + s_2 + c_2 - p_2$	$s_2 + i_2 + c_2$

This is obvious from the fact that any payment which is greater than or equal to $b + s + 2c$ will leave the supplier with a residual value of $-c$. Since the supplier can do at least equally well by not contracting, and letting the competitor become a category manager, a contract not satisfying this condition will be rejected.

Interestingly, however, the buyer can successfully negotiate a payment very close to the upper bound described in Lemma 1. To understand how, consider the following sequence of events:

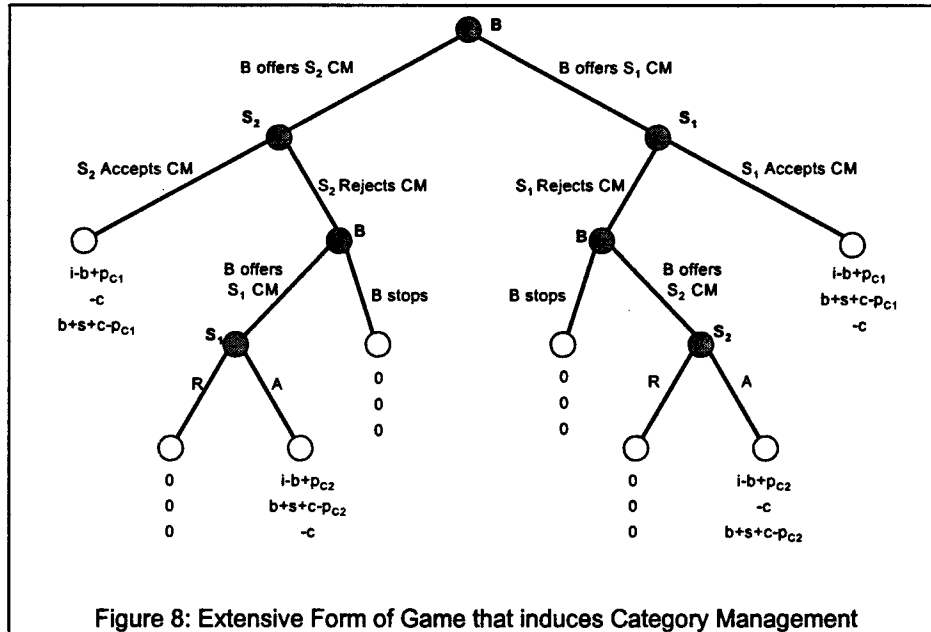
1. The buyer offers one of the suppliers a category management contract for a payment of p_{C1} .
2. If the contract is accepted, then the negotiation ends. If not, the buyer offers the other supplier a category management contract for a payment of p_{C2} . The other supplier either accepts or rejects the contract.

The extensive form of the contracting game corresponding to this sequence of events is shown in Figure 8. The payoffs made to B, S_1 and S_2 respectively after each sequence of actions are shown under the respective terminal nodes. The following result shows that the buyer can up with *more* than the value created by the information sharing transaction:

Proposition 1: If $p_{C1} < b + s + 2c$, and $p_{C2} > b + s + c$, then there are two equivalent subgame perfect Nash equilibria (SPNE) of the contracting game described: (B offers S_1 CM at p_{C1} , S_1 accepts) and (B offers S_2 CM at p_{C1} , S_2 accepts).

The proof of this is as follows. Consider the bottom left subgame, where S_1 has to decide whether to accept B's offer. If $p_{C2} > b + s + c$, this implies that S_2 's payoff from accepting is strictly positive. Hence the rational action at this node is for S_1 to accept. Now consider the node above that, where B decides whether to stop, or offer S_1 the category management contract. Since B knows S_1 will accept, B's only rational action is to offer S_1 the contract. (Note that this is why p_{C2} has to be less than $b + s + c$ —to make the threat credible). Proceeding up one more node, to where S_2 must decide whether to accept or reject the CM contract for a payment of p_{C1} . If S_1 refuses, the outcome will be that S_2 accepts later (as discussed), and hence S_1 's final payoff will be $-c$. If S_1 accepts, the payoff to S_1 is $b + s + c - p_{C1}$, which is strictly greater than $-c$. Hence, the only sequentially rational move for S_1 is to accept the contract, so long as $p_{C1} < s + b + 2c$. This shows that (B offers S_1 CM at p_{C1} , S_1 accepts) is an SPNE. The game is symmetric; the same sequence of arguments will show that the other set of strategies is also SPN.

This proposition implies that the buyer can not only extract all the value created from the supplier, but also an additional amount almost equal to the competitive



value generated for a supplier from gaining access to the information. In a sense, the supplier gets all the inventory savings, all the strategic value generated by S_1 , loses no bargaining power, and extracts the competitive value of the information from *both* the suppliers! We state a simple corollary to be used later; the corollary is immediate from Lemma 1 and Proposition 1.

Corollary 1.1: *It is possible for the buyer to get a total value of $s+2c+i-\epsilon$, $\forall \epsilon > 0$. However, the maximum value that the buyer can get from a category management arrangement is bounded above by $(b+s+2c+i)$.*

We now examine a generalization of the example discussed earlier. Specifically, there is another contracting game which proceeds as follows:

Stage 1: The buyer offers both suppliers contract individual VMI contracts at a payment of $p_1 = p_2 = p_V$

Stage 2: If both accept the contract, then the issue is settled. If one or both of them do not accept the contract, then the buyer does the following.

- If one of them has accepted, the buyer offers that supplier a category management contract for a payment of p_{C1} from the supplier to the buyer
- If neither of them has accepted, the buyer offers one of them a category management contract for a payment of p_{C2} from the supplier to the buyer

One can easily work out the final value for each party under the various different outcomes possible. These are summarized in Table A2:

Table A2: Payoffs to each firm under each outcome

Outcome	Buyer	Supplier 1	Supplier 2	Total Value
None	0	0	0	0
VMI (B - S1)	$i-b+p_v$	$s+b-p_v$	0	$s+i$
VMI (B - S2)	$i-b+p_v$	0	$s+b-p_v$	$s+i$
VMI (B - S1 and B - S2)	$2i-2b+2p_v$	$as+b-p_v$	$as+b-p_v$	$2i+2as$
S1 as category manager (under payment p_{c1})	$i-b+p_{c1}$	$b+s+c-p_{c1}$	-c	$s+i+c$
S1 as category manager (under payment p_{c2})	$i-b+p_{c2}$	$b+s+c-p_{c2}$	-c	$s+i+c$
S2 as category manager (under payment p_{c1})	$i-b+p_{c1}$	-c	$b+s+c-p_{c1}$	$s+i+c$
S2 as category manager (under payment p_{c2})	$i-b+p_{c2}$	-c	$b+s+c-p_{c2}$	$s+i+c$

The payoffs made to B, S₁ and S₂ respectively after each sequence of actions are shown under the respective terminal nodes. The following proposition characterizes the conditions under which the outcome of the example is the unique subgame perfect Nash equilibrium of the game:

Proposition 2: *If the following conditions are satisfied:*

1. $p_v < as+b+c$
2. $p_v < p_{c1} < c + \min\{p_v, 0.5(s+b+p_{c2})\}$

then the strategy (Supplier 1 accepts VMI, Supplier 2 accepts VMI) forms a part of every subgame perfect Nash equilibrium. Therefore, every SPNE of the game yields the payoffs $(2i-2b+2p_v, as+b-p_v, as+b-p_v)$ to B, S₁ and S₂ respectively.

A detailed proof of the proposition is omitted; however, the actions at each node that form a part of the precise description of one such SPNE outcome are listed below:

- **Node 1:** S₁ accepts VMI
- **Node 2,3:** S₂ accepts VM
- **Node 4:** B offers S₁ CM
- **Node 5:** B offers S₁ CM with 0.5 probability, B offers S₂ CM with 0.5 probability

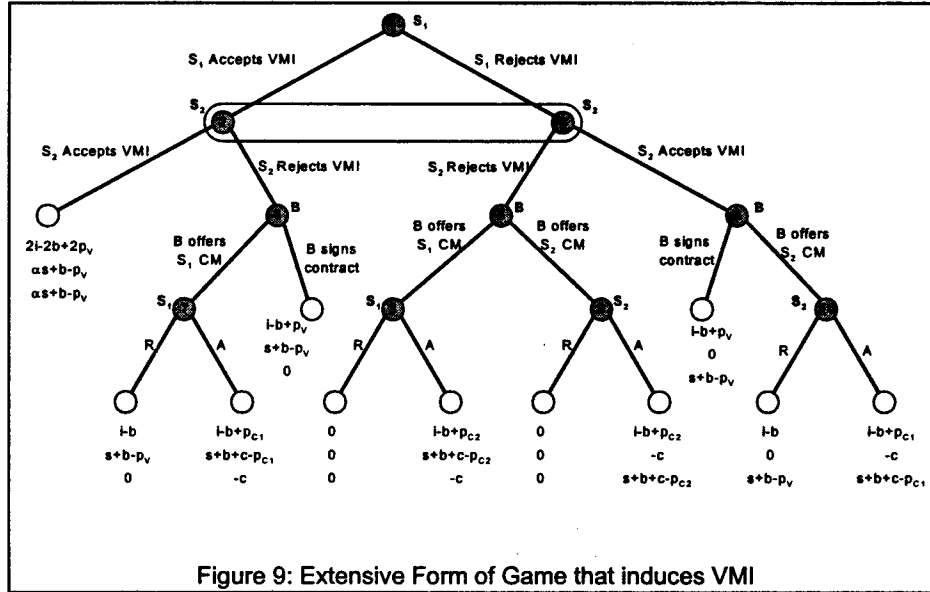


Figure 9: Extensive Form of Game that induces VMI

- Node 6: B offers S_2 CM
- Node 7,8 : S_1 accepts (A)
- Node 9,10: S_2 accepts (A)

The outcomes at nodes (7) through (10) are a consequence of condition 2. Once it is ensured that these are the only Nash outcomes at these nodes, the actions at (4) and (6) follow. Any pure or mixed strategy is optimal at node (5); however, a little thought will show that if any other mixed strategy forms part of an SPNE, then replacing that with the symmetric mixed strategy will not alter subgame perfection. Recall the example earlier in the text; the strategy at this node determines the expected payoffs if both S_1 and S_2 refuse, and is critical to the credibility of the threat. Finally, condition (1) ensures that the actions described at nodes 1,2 and 3 are sequentially rational

Note that on this scenario, the buyer's payoff is bounded above by $2\alpha s+2c+2i$. A result similar to Corollary 1.1 can easily be shown here. This leads to the question of whether the buyer should induce VMI as the final outcome, or category management. The following simple proposition characterizes this:

Proposition 3: *If $\alpha > 0.5(1 - i/s)$, then the buyer prefers VMI; if $\alpha < 0.5(1 - i/s)$, the buyer prefers category management; if $\alpha = 0.5(1 - i/s)$, the buyer is indifferent.*

Since we know the maximum feasible payoff to the buyer in each game, comparing these figures yields the result. The first implication is that *ceteris paribus*, as the level of competition in the supplier market increases, the buyer is

more likely to prefer category management. Also, as the level of strategic rent that the supplier could generate increases, category management becomes more likely. Finally, as the level of inventory savings for the buyer increases, VMI becomes more likely (this is fairly obvious without the analysis).

Note that the magnitude of competitive rent c is not a part of the decision; this is because the buyer can extract this in either case. However, it is a crucial determinant of how much a buyer will want an IOIS at all — as c increases, the benefits to the buyer increase. There are other modifications to the model (imbalance in size, asymmetric information) that could yield more insight; we defer that analysis to a more detailed and forthcoming research paper.

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