December 1997

Building and Sustaining Interorganizational Information Sharing Relationships: The Competitive Impact of Interfacing Supply Chain Operations with Marketing Strategy

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BUILDING AND SUSTAINING INTERORGANIZATIONAL INFORMATION SHARING RELATIONSHIPS: THE COMPETITIVE IMPACT OF INTERFACING SUPPLY CHAIN OPERATIONS WITH MARKETING STRATEGY

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Abstract

Information technology has radically altered the management of supply chain operations; many business partners who are adjacent on the supply chain can gain from entering *interorganizational information sharing (IOIS) relationships* and sharing information that was previously accessible to only one of them. This situation is typical in retailer-supplier logistics management relationships. The first part of this study analyzes different forms of virtual integration—relationships between independent companies that result in some of their operations resembling those of a single vertically integrated firm—and classifies them based on their models of information sharing across the supply chain. This study finds that there are four primary policies that firms adopt when they exchange information across the supply chain; these are EDI, vendor managed inventory (VMI), continuous replenishment (CR), and category management (CM).

Typically, corporations view the development of interorganizational information systems and the sharing of information as being targeted at increasing *operational efficiency* by reducing ordering costs, inventory costs, and supply lead times. Many studies have focused on studying IOIS technology issues and estimating the value generated from these arrangements using traditional models of inventory and ordering costs. However, this study finds that, in a number of cases, the information shared can have *cross-functional value*—it can also be used to improve a *supplier's* production planning and to alter their *marketing and sales* strategies. Paradoxically, however, suppliers who receive such information feel that not only are their benefits minimal, but they often end up *worse off* than before the IOIS was implemented.

The second part of the study explains this paradox. It shows how retailers and other buyers can successfully contract to end up with *more* value than is generated by the sharing of information. Using game-theoretic models of strategic interaction, it shows that this effect intensifies as the competitive value of the information to the supplier's marketing and sales departments increases. Besides, as the value that could be generated by the sales and production divisions of the supplier increases, the study demonstrates how the supplier loses *more and more value*. Furthermore, the buyer need not actually share the information to derive these rents; the study indicates why the

possibility of sharing is sufficient, *even* when the buyer cannot independently create value from that information.

The practical contributions of this interdisciplinary study are manifold. It provides a clear and lucid description of the different levels at which organizations share information. It also describes a fairly general modeling framework which lays the foundation for a deeper analysis of this increasingly important area. The strategic results demonstrate that a single focus on the technological or operational aspects of IOIS can mislead managers significantly. The true costs and benefits of these relationships can only be judged by recognizing the cross-functional impact of the information flows on the operational architecture, the marketing strategies of the suppliers and buyers, and the nature of competition within the respective organizations' industries.

1. INTRODUCTION

Recent advances in information technology have enabled low-cost and efficient interorganizational information sharing (IOIS) relationships between firms adjacent on the supply chain. These arrangements have been prevalent in the automotive industry for many years. For instance, Chrysler mandates that all its suppliers be able to interface electronically with their logistics management information systems. However, of late, IOIS arrangements have become more varied, and have also become common in a number of other industries; in particular, between large commercial retailers and their suppliers of OTC (over-the-counter) goods.

Several such arrangements have been studied. To illustrate some of the issues believed to be crucial to understanding their costs and benefits, consider the following real-life case:

XYZ 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.

XYZ 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 XYZ's order processing system. Currently, there are over 160 customers who use EDI for ordering. Seventy percent 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 five days. Customer order problems, which used to 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 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 XYZ.

> XYZ has solved these problems and achieved further operating improvements using VMI (vendor managed inventory). 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: XYZ controls the stock in the retailers stores. This eliminates the information gap discussed earlier. This information also has cross-functional value, as it allows XYZ to generate superior demand forecasts. It has increased the number of inventory turns by over 300%. Another of XYZ's retailers does not allow this form of VMI, but gives XYZ access to their POS information; this information is targeted at helping XYZ's marketing and sales divisions make better forecasts, and to give XYZ the option of replenishing stocks continuously. XYZ also manages a whole category of OTC pharmaceutical products for one of their retailers; this provides XYZ with valuable information about competing pharmaceutical companies' sales and promotion patterns.
>
> The benefits to XYZ should be immense; however, their managers do not feel that there is any tangible net value from these advanced systems. The efficiency of their logistics management and their marketing strategies have improved; however, these benefits seem to be outweighed by the fact that they operate on stringent and expensive supply schedules and are saddled with a number of the ordering costs that the retailer used to bear. In short, as one despondent manager put it: "The retailer seems to have extracted all the benefits of our partnership."

The case raises a number of interesting points. This study focuses primarily on the following issues:

- How much information should a firm share? If sharing information generates value, one might argue, then why not share all relevant information available? At least two observations are of consequence when examining the question of *up to what level must one build these relationships*:

  — The sharing of information also affects a different dimension of the buyer-supplier relationship: the *relative bargaining power* of the two parties.

  — The nature of the information shared may influence the strategies of *departments outside operations and supply chain management*; also, it may affect the *competitive position* of the buyer or supplier with respect to their *own* industry rivals.

  Based on field studies, section 2 describes the impact of different levels of information sharing on the operations, sales and marketing strategies of an organization.

- If these arrangements are indeed value creating, then a question which arises is *how can IOIS relationships be sustained?* For instance, a supplier may get tremendous operations and sales strategy 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. A model of the contracting process is presented in section 3. The model demonstrates that, although the supplier creates more value, the commonly observed buyer-takes-all outcome often emerges.

The conclusions in section 4 detail a number of counter-intuitive strategic guidelines and managerial insights.

Existing work in the area of interorganizational information sharing has covered a fairly wide range of topics. The earliest articles which indicated the shape these sharing relationships may take were by Cash and Konsynski (1985) and by Clemons and McFarlan (1986). The impact of EDI on buyer-supplier relationships has been studied by

Riggins and Mukhopadhyay (1994) and by Wang and Seidmann (1995). Bensaou and Venkatraman (1995) study interorganizational relationships in the U.S. and Japan, and develop and test a model based on the fit between information processing capabilities and needs. Clark and Stoddard (1996) discuss the cross functional value of EDI and continuous replenishment arrangements in the grocery industry and discover, among other things, that inventory reductions occur for both buyer and suppliers. Their study is based primarily on four cases, descriptions of which can be found in Clark et al. (1994), Clark and McKenney (1994, 1995), and Schiano and Clark (1995). Whang (1993) examines whether a seller should share queue information with a customer. The ability to share information across organizations creates a move toward more transactions with fewer suppliers, and this is explained in part in Clemons et al. (1993). The impact of IT on coordination and bargaining power is studied by Bakos and Brynjolfsson (1993) and Clemons and Row (1993). An interesting case study of IOIS can be found in Clemons and Row's (1988) study of the Economost system at McKesson Drug Company (this is a popular case in MBA courses for illustrating strategic information systems). In related work, Henderson (1990) studies the relationships between IS and line managers. One of his findings—that a critical determinant of partnership is mutual dependence on distinctive competencies and resources—is particularly relevant to the IOIS relationships modeled here. An interesting study of the impact of the potential incompleteness of contracts involving information assets is done by Brynjolfsson (1994).

2. THE LEVEL OF INFORMATION SHARING

The diversity of information content and the numerous sharing options makes it seemingly impossible to classify the nature or level of information sharing. Field studies for this research have indicated that a number of different sharing arrangements are possible. For example, some suppliers share *inventory position information* of the products a certain supplier sells them. This information may be transmitted daily, or weekly; the level of detail also varies. There are suppliers who see the store-level day-to-day *point-of-sales (POS) information*; there is a great deal of variety here as well: some see only product UPC's and quantities, while others have access to temporal sales distribution and customer profiles. Other buyers transmit order quantity, payment, and cost information using EDI; this is a situation where the volume of information exchanged may be great, but its impact on the operations of the firms are relatively low.

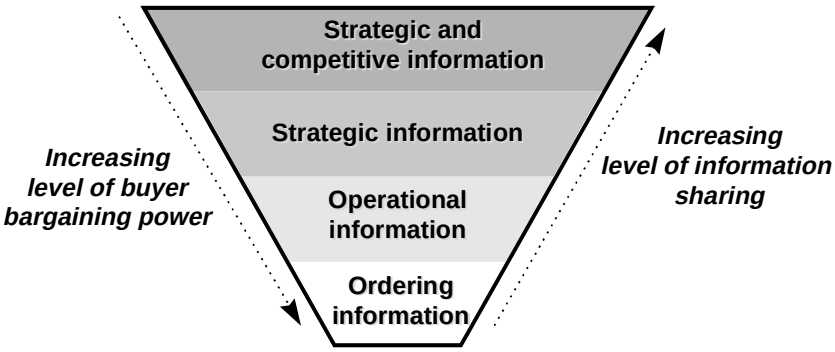

Figure 1. Models of information Sharing

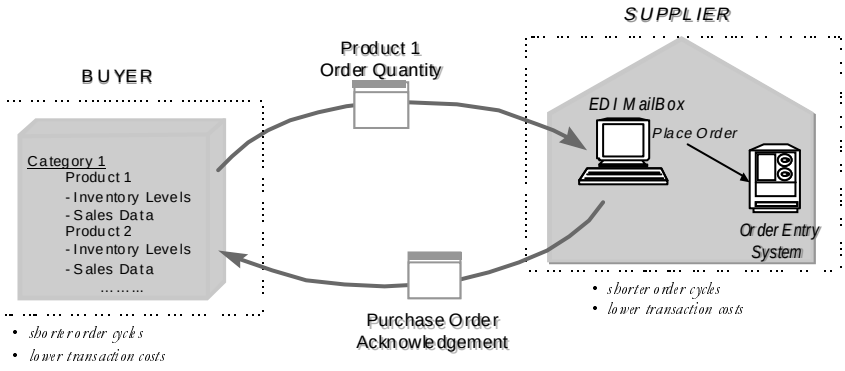

Figure 2. EDI—Exchanging Transaction Information

If one examines information from another perspective, the problem simplifies a great deal. This study treats the level of information shared not based on what its *exact content or volume* is, but rather, based on the *impact it has on the operations, sales, marketing, and production strategies* of the parties that contract to share the information. Using this view, one can classify IOIS arrangements into four categories, based on the level of impact the shared information has on the buyer and supplier (Figure 1).

The first level involves increased cost-and-time-effective exchange of transaction-level information (like order quantities and prices) through EDI. The second level involves sharing select operational information (such as inventory levels) in order to exploit superior expertise across organizational boundaries and improve operating 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.

2.1 Exchanging Order Information

Many IOIS arrangements do not involve sharing firm-specific operations information; they merely improve logistics processes through efficiency gains from EDI. The study treats this case—where the companies exchange ordering information—as the base case. (Figure 2). This is one of the oldest and most widely prevalent forms of IOIS, and is aimed at reducing transactions costs and the duration of order cycles.

At this level, 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, Wang and Seidmann 1995); subsidies are a common solution to this problem.

2.2 Sharing Operations Information

Information is often shared to leverage on the superior expertise, or operational economies-of-scale of one organization. This occurs when one firm owns valuable information, while the other firm possesses the ability to use this information. An example of this is vendor managed inventory (Figure 3). For instance, a buyer shares aggregate inventory position information with its suppliers; this enables suppliers to manage the inventory of their own products

at the buyer's site. Suppliers are better equipped to perform these duties for the following reasons: They have experience managing large supply side inventories of this product. They have superior knowledge of production schedules, which reduces the supply-side uncertainty that a buyer normally faces, resulting in a lower average inventory for the buyer. They could have comparable VMI arrangements with a number of buyers (economies-of-scale).

Efficiency gains are not restricted to inventory cost reductions. In the case presented in section 1, when product specifications, packaging specifications, or packaging quantities changed, an order sent with an outdated UPC would generate rework. 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*.

What does the supplier gain? Their internal operating efficiency gains are minimal at best. However, one benefit that may not be immediately tangible (if it exists) is that the supplier's *relative bargaining position* for its transactions with the buyer may improve. Since it is has superior knowledge of how well or badly its product is doing on a regular basis, the information asymmetry it faces reduces; it may therefore be able to bargain for price schedules that are more favorable.

It is likely that the contracts underlying these sharing agreements will include a 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, despite the apparent gain in power by the supplier as described in the previous paragraph) to some kind of price advantage that the buyer passes on to the supplier. The discussion in section 3 provides insight into some these issues.

2.3 Sharing Strategic Marketing Information

It is becoming common for organizations to share brand-specific information which provides strategic benefits to one of the organizations and also leverages on their superior expertise. This occurs when one organization owns information that it can derive little independent value from, but which another can use to generate operational benefits for the company it receives the information from, besides garnering strategic value for its own sales and

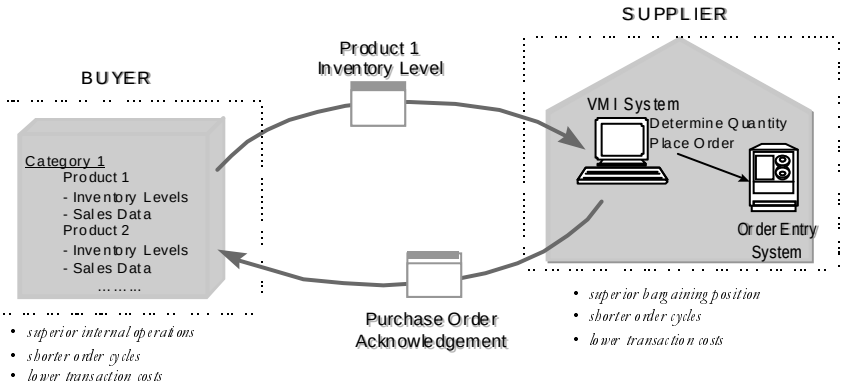

Figure 3. VMI—Sharing Operational Information

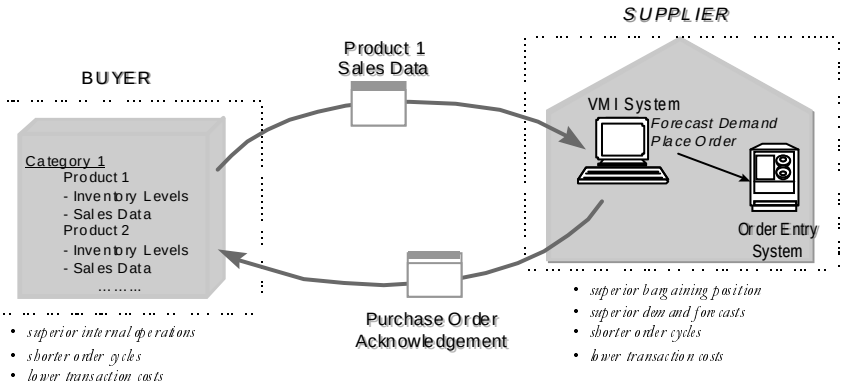

Figure 4. Continuous Replenishment—Sharing Strategic Information

marketing departments. For instance, a retailer possesses POS (point-of-sales) information on all of 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 information from many retailers. This form of information sharing is used in the efficient customer response, continuous replenishment, and quick response systems models (Figure 4), common in the grocery and fashion retailing industry. The model has been discussed for many years now: supply chain management has always striven to move towards a system where consumer purchases "pull" goods through the chain, rather than suppliers "pushing" them. 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.

Since inventory positions can easily be derived from POS information, the operational information that was the topic of subsection 2.2 is also being shared. Hence, all of the benefits that accompany VMI-type situations still exist. However, this information is of a much higher level of detail than inventory aggregates. It can be used by the supplier's sales and product development groups for improved demand forecasting, promotion scheduling, and segment-specific forecasts. 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 (Chase 1996). Reduced demand uncertainty also improve the internal inventory management of the supplier. The benefits described above may indicate that the buyer can induce suppliers unwilling to enter into information sharing agreements described in subsection 2.2 by offering them access to information that is of strategic value. However, when this information is available to the supplier, the relative bargaining power of the buyer is reduced further. 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.

2.4 Sharing Strategic and Competitive Marketing and Sales 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 the supplier with strategic and competitive benefits. This occurs when one organization possesses information that it can derive little independent value from, but from which another can derive internal strategic production benefits, as well as competitive sales and marketing benefits (Figure 5). The competitive bene-

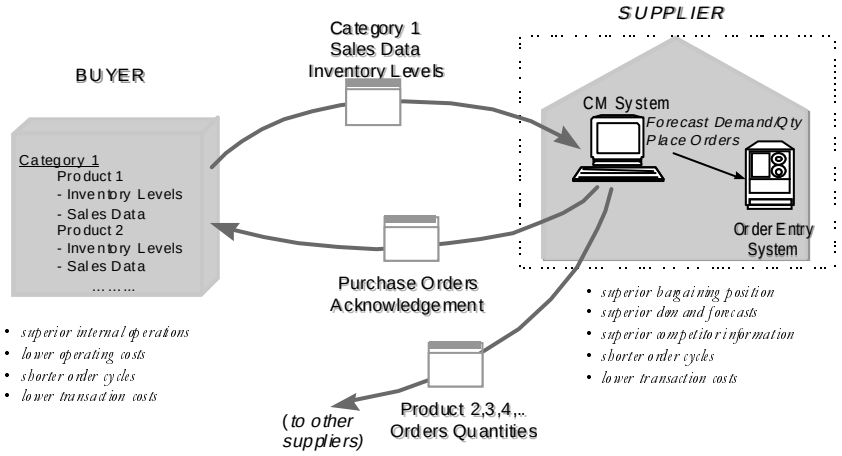

Figure 5. Category Management—Sharing Strategic and Competitive Marketing Information

fits 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.

The retailer endows one of the suppliers with inventory management responsibility over *all of the products supplied* for that category and provides them with the relevant POS information. This 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 also gains tremendously when provided access to this information. Not only are all the benefits of subsection 2.3 present, but the supplier can track the sales of competing products in the category and use this information to improve the sales strategy of their own product. Since there may be a 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 gains a cost advantage as well. The tradeoff appears to be increased transaction costs for the supplier, who manages, orders, and monitors product movements of a whole category of products.

This section discussed the sources of value creation when two companies share information at different levels. Section 3 examines how this value will be shared by the two firms.

3. COMPETITIVE ANALYSIS OF VALUE SHARING: WHY THE "BUYER TAKES ALL"

The market for this study is modeled with one buyer (B) and two competing suppliers (S_1 and S_2). Each supplier *k* manufactures one product, called product *k*. Three situations are examined: no information sharing, VMI with POS data transfer (continuous replenishment), and category management.

3.1 General Framework for Analyzing Value Sharing

As discussed in detail in section 2, the value from information sharing is generated by the following factors:

1. *Operational savings for the buyer:* If the buyer shares demand information (POS) about product *k* with supplier *k* then this results in cost savings of i_k for the buyer. These are the savings from reduced inventory and ordering costs described in subsections 2.2 and 2.3 (see chapters 4 and 5 of Nahmias 1996, or see Linwood and Montgomery 1974, for more discussion on inventory costs).

2. *Strategic sales and marketing revenue for the supplier:* If supplier *k* has *exclusive* access to demand information about product *k*, then the supplier gains an amount s_k (as described in subsection 2.3). If both suppliers have access to their respective demand information, then they both gain qs_k. q lies between 0 and 1, and represents the competitive environment; q close to zero implies a highly competitive supplier market, and q close to 1 implies a very low degree of competition between suppliers. The remaining gains of $(1-q)s_k$ per product are captured by the consumers.

3. *Competitive marketing revenue for the suppliers:* If supplier *k* has access to both its own demand information, and to that of supplier *j*, then supplier *k* gains competitive value of c_k and supplier *j* loses an equal amount (these are the competitive revenues described in subsection 2.4). Strictly, this is not value creation, as it is a zero sum situation; however, if B and S_k contract, they are jointly better off by this amount (even though S_j loses, it still represents value addition for B and S_k). See Chapter 9 of Lilien et al. (1992) for further details of the competitive aspects of distribution, or any standard microeconomics text (for instance, MasColell et al. 1995, Chapter 10) for a discussion of competition in an oligopoly. There are also the following transfers made, depending on the nature of the information exchanged:

    a. *Bargaining power transfers:* If supplier *k* has access to their own demand information, then the buyer loses b_k—this reflects their loss in bargaining power (as described in subsections 2.2 through 2.4). Supplier *k* gains this amount b_k.

    b. *Contractual payments:* When B contracts with S_k, there is a transfer payment of p_k from S_k 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_k can be negative.

    Now, there are six possible situations:
    1. No information exchange
    2. VMI between B and S_1
    3. VMI between B and S_2
    4. VMI with both S_1 and S_2
    5. S_1 as category manager
    6. S_2 as category manager

The costs and benefits to each party under each arrangement, along with the net value created are summarized in Table 1.

This is the general framework. The analytical scope of this particular paper restricts us to assuming that the suppliers are identical, i.e., $i_1 = i_2 = i$, $c_1 = c_2 = c$, and so on.

Table 1. Payoffs Under Different Sharing Arrangements

Sharing Arrangement	Buyer			Supplier 1			Supplier 2			Total
	v	p	net	v	p	net	v	p	net	Value
None	0	0	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	$i_1+i_2-b_1-b_2+p_1+p_2$	qs_1+b_1	$-p_1$	$qs_1+b_1-p_1$	b_2+qs_2	$-p_2$	$b_2+qs_2-p_2$	$i_1+i_2+q(s_1+s_2)$
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*	$-c_2$	$b_2+s_2+c_2$	$-p_2$	$b_2+s_2+c_2-p_2$	$s_2+i_2+c_2$

3.2 Inducing One Supplier to be a Category Manager

First, the case in which the buyer wishes to make one of their suppliers a *category manager* is examined. The value that is generated from this arrangement is $s+i+c$. In the absence of competition, one would expect them to share this value equally (that is the predicted Nash bargaining outcome; see MasColell et al. 1995, Chapter 22). It is 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 can potentially get more value from the supplier through creative contracting. Let the payment from the chosen supplier to B be denoted p_{C1}. The following result follows:

> ***Proposition 1:*** *The transfer payment p_{C1} is strictly less than the sum of the gain in bargaining power, potential gain in strategic value, and twice the potential gain in competitive value, i.e., $p_{C1} < b+s+2c$.*
>
> *(All analytical proofs and extensive forms of the subsequent contracting games are in the technical appendix.)*

Proposition 1 follows from the fact that any payment which is greater than or equal to $b+s+2c$ will leave the supplier with a residual value less than $-c$. The supplier can do better by not contracting; hence, a contract not satisfying this condition will definitely be rejected.

Interestingly, however, the buyer can negotiate a payment very close to this bound. 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 following result shows that the buyer can end up with *more* than the value created by the information sharing transaction:

> ***Proposition 2:*** *If $p_{C1} < b+s+2c$, and $p_{C2} < b+s+c$, then there are two equivalent rational outcomes of the contracting game described:*
>
> 1. *B offers S_1 category management at p_{C1} and S_1 accepts the offer.*
> 2. *B offers S_2 category management at p_{C1} and S_2 accepts the offer.*
>
> *(By rational outcomes, we mean subgame-perfect Nash equilibria (SPNE); the reader is referred to any text on game theory—for instance, Fudenberg and Tirole 1991, Chapter 3.5—for a discussion of this equilibrium concept.)*

Intuitively, the result follows from the fact that if the value of the payment p_{C1} satisfies the first inequality, the first supplier (say, S_k) has to accept the terms of the contract (payment of p_{C1}); not accepting them will make that supplier worse off (when the other supplier S_j accepts subsequently). The second inequality ensures that the threat of the buyer to offer the second supplier the contract at p_{C2} is *credible*.

This result shows 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 of the inventory savings, all of the strategic value generated by S_1, loses no bargaining power, and extracts the competitive value of the information from *both* the suppliers!

A simple follow-up proposition is stated; it follows from propositions 1 and 2.

> ***Proposition 3:*** *It is possible for the buyer to get any total value that is strictly less than, but very close to, $s+2c+i$. However, the buyer can never get a total value greater than $(s+2c+i)$.*

This proposition indicates the maximum value a buyer can get from a category management arrangement; as mentioned earlier, this is *more* than the actual value created (which is $s+c+i$) from the information sharing arrangement.

3.3 Inducing Both Suppliers to Manage Their Inventory

A situation is now modeled where the buyer wants both suppliers to manage their own inventories. At first glance, the nature of the desired outcome (that both suppliers independently contract with the buyer) leads one to believe that there will be genuine value *sharing* in this case, and the buyer will not end up extracting everything from the suppliers. However, this is not the case in practice, and the next result shows why.

Consider the following sequence of offers. All payments are from supplier to buyer.

- **Stage 1:** The buyer offers both suppliers 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. Otherwise:
  - — If one of them has accepted, the buyer offers that supplier a category management contract for a total payment of p_{C1}.
  - — If neither of them has accepted, the buyer randomly offers one of them a category management contract for a payment of p_{C2}.

Table 2. 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)	$2i-2b+2p_V$	$qs+b-p_V$	$qs+b-p_V$	$2i+2qs$
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})	$i-b+p_{C1}$	$-c$	$b+s+c-p_{C1}$	$s+i+c$

The final values for each party under the different possible outcomes are summarized in Table 2. The next proposition characterizes the values of the transfer payments that the buyer must offer which ensure that the *unique* rational outcome (SPNE) of the contracting game is both suppliers accepting VMI, at rather unfavorable terms to themselves.

Proposition 4: *If the following conditions are satisfied:*

1. $p_V < s+b+c$
2. $p_V < p_{C1} < c+min\{p_V, 0.5(s+b+p_{C2})\}$

then every rational outcome of the sequence of offers above must include both Supplier 1 and Supplier 2 accepting VMI. Therefore, every rational outcome yields the following payoffs to the three firms:

- B: $2i-2b+2p_V$
- S_1: $qs+b-p_V$
- S_2: $qs+b-p_V$

The first condition ensures that the suppliers participate in the arrangement (i.e., that they are better off by participating than by refusing to). The second condition ensures that the threat of offering category management (if one of the suppliers chooses not to participate in VMI) is credible, i.e., it is beneficial for both the buyer and supplier at that stage of the contracting process.

A result similar to proposition 3 is now stated. .

Proposition 5: *It is possible for the buyer to get any total value that is strictly less than, but very close to, 2qs+2c+2i by inducing both suppliers to adopt VMI. However, the buyer can never get a total value greater than (2qs+2c+2i).*

Again, note the phenomenon of the buyer gaining more than the value created (*2qs+2i)* from the sharing arrangement. Now, propositions 3 and 5 have indicated how high the value extraction of the buyer can go in each of the two situations. Any rational buyer faced with these choices goes for the better option:

Proposition 6: *If q > 0.5(1 - i/s), then the buyer prefers VMI; if q < 0.5(1 - i/s), the buyer prefers category management; if q = 0.5(1 - i/s), the buyer is indifferent.*

Since the maximum feasible payoff to the buyer in each game is known (from propositions 3 and 5), 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 value that the supplier can generate increases, category management becomes more likely. Finally, as the level of inventory savings for the buyer increases, VMI becomes more likely.

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 whether a buyer will want an IOIS at all—as c increases, the benefits to the buyer increase.

The modeling framework in subsection 3.1 allows for a much deeper analysis of other situations as well (imbalance in size, asymmetric information) that are unfortunately beyond the scope of this paper. The description of this analysis is deferred to a forthcoming, more detailed research paper.

4. 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 IOIS arrangements. There has also been significant concern on the part of suppliers who see no tangible benefits accruing to them from different information sharing arrangements. This study offers the following insights into these long-standing concerns.

1. The impact of IOIS relationships is not merely operational; they can alter supplier marketing and sales strategies and shape competition in supplier markets.

2. It is possible for a buyer to extract *all* of 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—a realistic threat of potential sharing is sufficient.

3. In a supplier market with many competing suppliers of similar size, VMI is likely to be the best policy for a buyer; although 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 increase the operational savings that a supplier expects from IOIS relationship:

   - High inventory cost rates
   - High demand uncertainty

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

5. Buyers should target suppliers who have the characteristics described in (4), as they are likely to be tempted by the prospects of high 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.

6. Partnering with suppliers (as advocated by many supply chain management information systems vendors) is unlikely to be optimal for the buyer in many situations. There is little reason for buyers to be worried about loss in bargaining power when they share information; through creative contracting, they can regain any power they apparently lose.

7. A supplier in an IOIS relationship is often unlikely to benefit from the relationship, or accrue any of the value generated; however, it may still be necessary to remain in the arrangement to avoid further losses. A supplier who breaks even on a VMI or category management agreement is probably doing as well as they can.

8. As information technology enables buyers to use and share 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 marketing or sales information that is potentially very valuable to a supplier, this is not a sign of *the supplier benefiting a lot, but a predictor of all suppliers losing a lot.*

9. As the cost of processing and sharing information drops, as it evidently has and will continue to do (Moore's Law, Gilder's Law), 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

In light of this analysis, this spells more profits for the buyer, and more value extraction from suppliers.

These results may appear to be prophecies of doom for suppliers; however, rather than remaining in denial, they need to understand the nature of their relationships and try to organize them as favorably as they can. Ongoing studies are aimed at modeling precisely the effect of technology and competition on contracting in a heterogeneous supplier market. An investigation is also being conducted on the issue of asymmetric information about the value of the information and the potential incompleteness that the contracts over information shared could have.

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TECHNICAL APPENDIX

Proof of Proposition 1

Without loss in generality (as the suppliers are symmetric), supplier 1 is the category manager. By *choosing* to be the category manager, the net gain for the supplier is $-p_{C1}+b+s+c$. If, on the other hand, the supplier had chosen *not* to be a category manager, in the worst case, their net gains are $-c$ (in the case that supplier 2 becomes the category manager). Supplier 1 is rational, and hence should be better off by choosing to be the category manager, i.e.,

$$-p_{C1}+b+s+c > -c$$

Rearranging the terms, we get

$$p_{C1} < b+s+2c$$

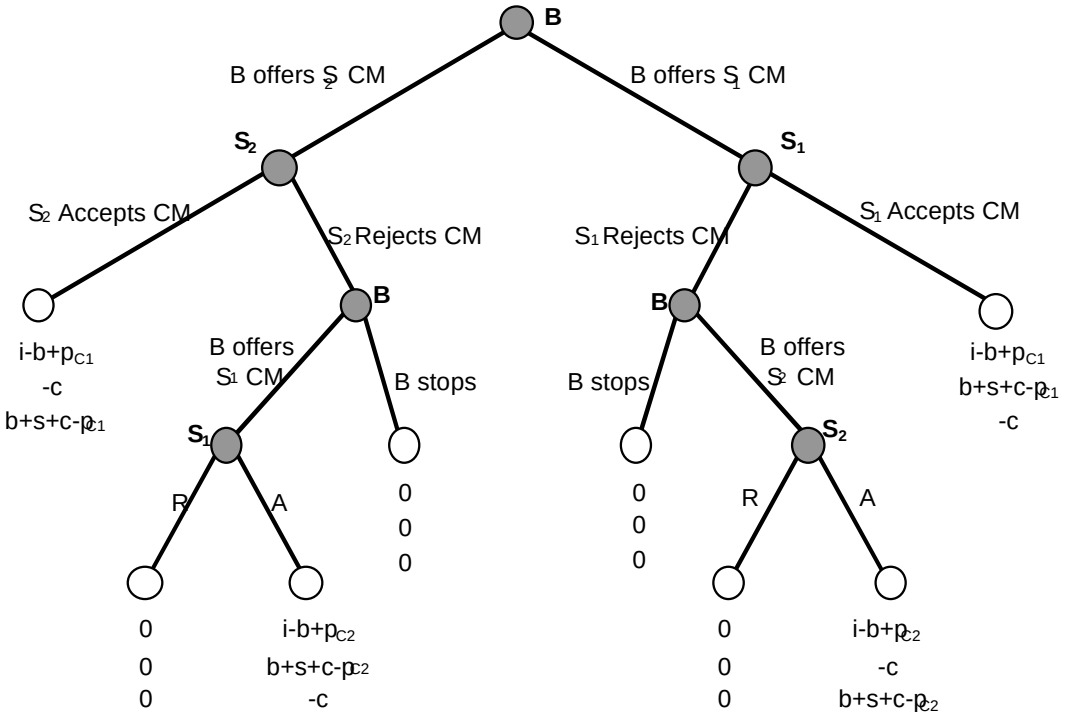

Figure 6. Extensive Form of Contracting Game That Induces Category Management

Proof of Proposition 2:

The extensive form of the contracting game described in subsection 3.1 is shown in Figure 6. 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.

Proof of Proposition 3:

Denote the net gain for the buyer from a category management arrangement as n.

Now, $n = (p_{C1} + i - b)$. However, from proposition 1,

$$p_{C1} \leq b+s+2c$$
$$\Rightarrow n+b-i \leq b+s+2c$$
$$\Rightarrow n \leq s+2c+I$$

Therefore, a buyer can never get total value greater than $s+2c+i$.
Consider any $p_{C1}=b+s+2c-e$, $\varepsilon > 0$. So long as $p_{C2} > b+s+c$, the buyer can induce category management with this payment, for any $\varepsilon > 0$ (this follows from proposition 2). Hence, the buyer can get a total value of

$$n = (b+s+2c-\varepsilon) + i - b$$
$$= s+2c+I-\varepsilon \text{ for all } \varepsilon > 0.$$

Proof of Proposition 4:

The extensive form of the game described in subsection 3.2 is shown in Figure 7. The actions at each node that form a part of the precise description of one such SPNE outcome are listed below:

- Node 1: S_1 accepts VMI
- Node 2, 3: S_2 accepts VM
- Node 4: B offers S_1 CM
- Node 5: B offers S_1 CM with 0.5 probability, B offers S_2 CM with 0.5 probability
- 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. 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.

Proof of Proposition 5:

Similar to proposition 2; follows directly from proposition 4.

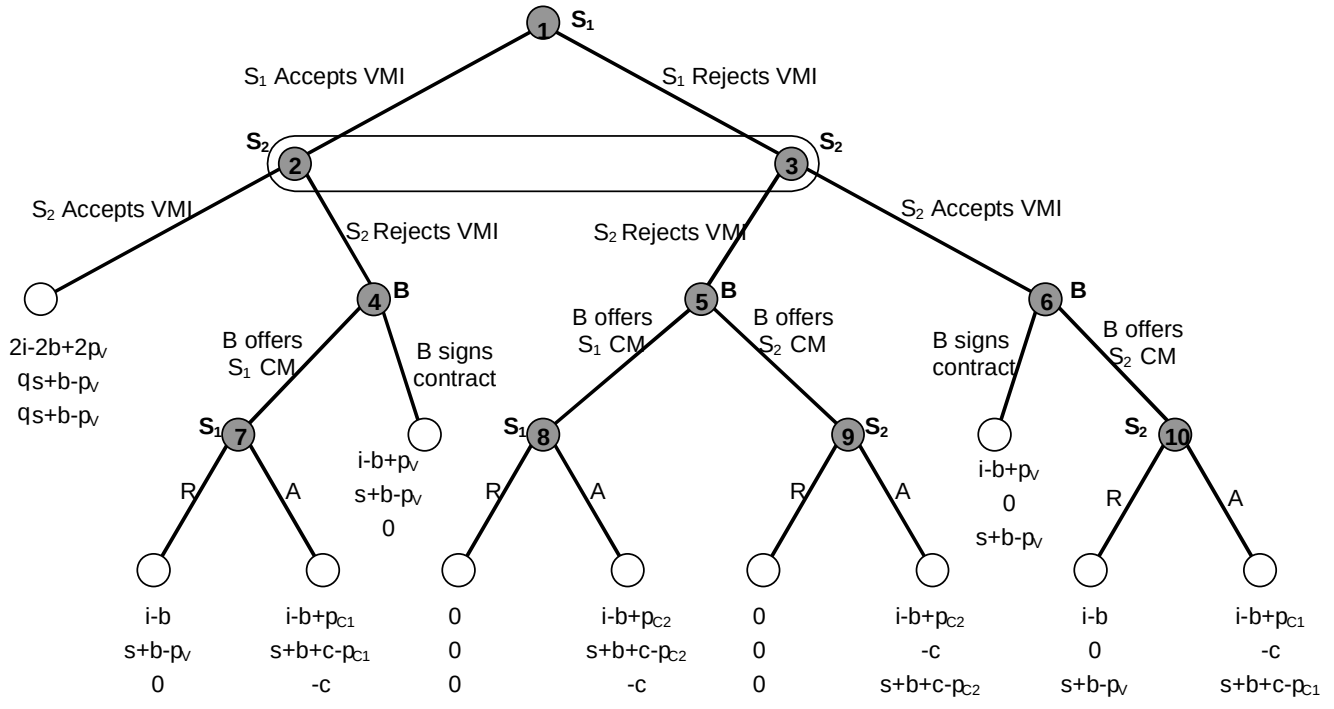

Figure 7. Extensive Form of Contracting Game That Induces VMI

Proof of Proposition 6:

From proposition 3, the maximum equilibrium payoff to the buyer under category management is $C = (s+2c+i)$ (this is when the supplier is indifferent between accepting and rejecting the contract). Similarly, from proposition 5, the maximum equilibrium payoff for the buyer under VMI is $V = (2qs+2c+2i)$. First, let us consider the case that $q > 0.5(1-i/s)$. This implies that:

$$V = 2qs + 2c + 2i > 2 \times 0.5 \times (1 - \frac{i}{s})s + 2c + 2i$$

$$\Rightarrow V > s - i + 2c + 2i$$

$$\Rightarrow V > s + 2c + i$$

$$\Rightarrow V > C$$

This leads the buyer to prefer VMI. The equality and < cases follow in the same fashion.