

INFORMATION SHARING IN SUPPLY CHAINS: A LITERATURE REVIEW AND RESEARCH AGENDA

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*Working Paper 24/06
August 2006*

**DEPARTMENT OF MANAGEMENT
WORKING PAPER SERIES
ISSN 1327-5216**



Abstract

Information sharing is a vital aspect of coordination amongst parties in a supply chain. Information sharing can increase supply chain efficiency by reducing inventories and smoothing production. Supply chain efficiency is highly important as today's competition is no longer between companies, but between supply chains. This review discusses the impacts of information sharing in supply chains. The two perspectives used are the degree and the value of information sharing. The degree of information sharing relates to choosing the partner with whom information should be shared, the type of information shared, and the quality of shared information. The paper discusses the potential benefits of information sharing, noting that these benefits may be shared unequally amongst parties and consumers. Using these two perspectives, several research questions pertaining to information sharing in supply chains that merit research are identified.

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INTRODUCTION

In modern highly competitive markets, there has been a reorientation of management practices toward collaboration between trading partners. Strong collaboration between supply-chain partners is an important way of sustaining companies' competitive advantages. Intensified competition is no longer between individual companies, but between supply chains (Cooper, Lambert et al. 1997; Blackwell and Blackwell 1999; Lambert and Cooper 2000). Companies must broaden their area of analysis and decision making to encompass not single business units but whole supply chains (Lee and Whang 2000). Supply chains comprise three important flows: material, information and finance. Managing the coordination and integration of these flows within and across companies is essential to achieving effective supply chain management. Effective supply chain management is a pre-requisite to quality of service and profitability.

Information sharing is basic to effective coordination in a supply chain. Many studies have found that information sharing has great impacts on supply chain performance, especially in reducing the bullwhip effect (For example: Lee and Whang 2000; Xu, Dong et al. 2001; Yu, Yan et al. 2001). Information sharing enables companies to make better decisions in their operation leading to better resource utilization and lower supply chain costs. Better management of information allows companies to be more responsive to customers' demands (Lee 2000; Mentzer 2004).

Advances in information and communication technology (ICT) enable companies to share information. For example, the Internet allows organization to transfer digital data instantly and with high fidelity at nearly zero marginal cost. There are no technical obstacles, the fundamental questions are: what information should be shared, with whom should it be shared, and how it should be shared to optimize competitiveness and profitability? This paper will review the relevant literature and suggests major research questions

Simchi-Levi et al. (2003) define a supply chain as network of companies comprising suppliers, manufacturers, warehousing centres, distributors, and retailers; and raw materials, intermediate and finished products that flow between them. Information and financial flows are also important and govern physical flows. A supply chain can also involve third parties that provide logistics activities (Mentzer, DeWitt et al. 2001).

WITH WHOM SHOULD INFORMATION BE SHARED?

This question can be approached from different perspectives. First, how far information should be shared both upstream and downstream in a supply chain? And which partners at each stage should be involved? These decisions are related to the structure of supply chain (D'Amours, Montreuil et al. 1999).

Supply chain structure is how companies are arranged to form a supply chain and how all activities are linked (Cooper, Lambert et al. 1997; Lambert, Cooper et al. 1998; Lambert and Cooper 2000). An individual company can participate in a number of supply chains (Cooper, Lambert et al. 1997; Mentzer, DeWitt et al. 2001). Cooper et al. (1997) suggest that companies need to determine carefully with which partners of supply chains they should be closely integrated. Cooper et al. also point out that level of integration depends on various factors including firm capabilities, the complexity of products, and corporate culture.

As information sharing is the foundation of supply chain integration (Lee 2000), decisions on the level of integration are strongly correlated with decisions on what information should be shared and how it should be shared. Cooper et al. (1997) contend that designing the configuration of the

supply chain is not merely determining with whom companies should integrate but also designing how a company's activities are linked to those of their partners and deciding what information should be made accessible by partners.

Research determining with which partners in a supply chain a company should share information is very limited. Raghunatan (2003) examines demand information sharing in a supply chain comprising a manufacturer serving many retailers and analyses the optimal number of retailers that should be involved in information sharing. He found that the supplier will more likely to include more sharing partners when demands amongst retailers are independent, as the value of information sharing will increase significantly with the increasing number of sharing partners. This study confirms Cooper et al. (1997) argument that decisions on how many retailers should be involved in information sharing depends on product characteristics. The correlation of demand amongst retailers depends on the nature of products, consumer segments, and geographical location of partners (Raghunatan 2003). Lee, So and Tang (2000) also found that benefits of information sharing increase with the number of retailers involved when the demand processes variance are correlated over time.

One approach is to consider how many stages up and down the supply chain should company share information with. This is particularly important as the implementation of information sharing is not costless (Lee and Whang 1999) and may require significant changes in companies' business operations (Gavirneni 2002; Kulp, Lee et al. 2004). Lau et al (2002) examined various combinations of sharing between stages in a supply chain comprising a manufacturer, two distributors, and two retailers. Four combinations of sharing demand and inventory levels were studied: no information sharing; sharing demand and inventory level between retailers and distributors only; distributors and the manufacturer; and full information sharing. Counter-intuitively, the second mode of information sharing resulted in the highest total supply chain cost compared to other modes, even that of no information sharing. The lowest total cost was gained in the full sharing mode. Note that not all firms benefited from information sharing.

The next question is which partners in each stage should be involved and what factors affect that decision. Huang and Gangopadhyay (2004) studied various degree of information sharing in a four-stages supply chain comprises customers, retailers, distributors, wholesalers, and manufactures, in which each stage comprises several players. Three scenarios are analysed: no information sharing; partial information sharing (only 50% of trading partners in each channel involved); and full information sharing. The simulation study found that increasing degree of information sharing resulted in decreased inventory levels at wholesalers. The benefits are higher when demand is highly variable. The study concluded that parties obtain different benefits from information sharing.

Walter et al. (1999) studied a supply chain comprising a manufacturer, distribution centres and retailers that used the vendor managed inventory (VMI) program, where a supplier is responsible for replenishing retailers' inventory. The study found that the manufacturer's inventory is reduced even by low level adoption of VMI and that even non-VMI partners gain benefits. Contrary to the previous study, demand variance did not significantly affect the benefits. Smaros et al. (2003) studied a three levels supply chain in which the manufacturer used a combination of order data from non-VMI customers and sales data from VMI customers in its production planning. The study showed that manufacturer benefited from even a partial increase of involvement of its partners. This study only considered products with stable demand but included 21 products with different replenishment frequencies. Products with low replenishment frequency obtained more benefits with increasing information sharing.

The above discussion demonstrates that information sharing can be beneficial in at least some circumstances. However, the question of which partners should be recruited and recruitment criteria remain unclear. Partner selection in supply chains involves complex processes ranging from strategic to operational (Mentzer, Min et al. 2000). Companies must evaluate their partnering orientation which is the pattern of shared values and beliefs between partnering companies.

Mentzer (2004) further insists that it is not possible to include all supply chain members. Potential partners must be identified based on their importance to companies' competitive advantage. Shore and Venkatachalam (2003) proposed a method to evaluate partners' capabilities in information sharing. But this method only considers one aspect of partner selection. Therefore, the following research questions are proposed:

- How far up and down should information be shared in a supply chain?
- What are the criteria for the partner selection process?
- How does the information sharing between two parties in a supply chain affect others who do not involve?
- Will a company's competitive positions affect the decision on selection of partners? Or will information sharing change a company's competitive positions amongst others who not been involved?

WHAT INFORMATION SHOULD BE SHARED?

The information in a supply chain can be classified in different ways e.g. strategic or tactical; logistical; or pertaining to consumers (Mentzer 2004). Lee and Whang (2000) discuss various types of shared information and their potential benefits. For example, sharing order status can improve the quality of customer service, reduce payment cycles, and reduce labour cost. Sharing retail sales data can mitigate the bullwhip effect. Huang et al (2003) sort information into six categories pertaining to product, process, resource, inventory, order, and planning (see Table 1).

Table 1: Classification of production information (Huang, Lau et al. 2003)

Category	Production Information	Category	Production Information
Product	Product Structure	Resource	Capacity Capacity Variance
Process	Material Lead Time Lead Time Variance Order Transfer Lead Time Process Cost Quality Shipment Set-up Cost	Order	Demand Demand Variance Order Batch Size Order Due Date Demand Correlation
Inventory	Inventory Level Holding Cost Backlog Cost Service Level	Planning	Demand Forecast Order Schedule Forecasting Model Time Fence

Table 2: Types of shared information in the literature

Authors	Shared Information
Boone et al. (2002)	demand, forecast
Bourland et al. (1996)	demand
Cachon and Fisher (2000)	demand, inventory
Cachon and Lariviere (2001)	demand, demand forecasts
Chen (1999)	inventory, order
Chen et al. (2000)	demand
Croson and Donohoue (2003)	sales
Huang and Gangopadhyay (2004)	demand
Karaesman et al (2002)	advance order
Kulp et al (2004)	inventory level, warehouse, consumer info
Lau et al. (2002)	demand, order, inventory
Lee and Whang (1999)	demand
Lee et al. (2000)	demand
Mitra and Chatterjee (2004)	demand
Owen and Levary (2002)	demand, inventory
Ozer (2003)	advance demand
Raghunathan (2003)	demand
Simchi-Levi and Zho (2003)	demand
Smaros et al. (2003)	demand
Waller et al (1999)	inventory level , demand
Wang and Seidmann (1995)	demand
Xu et al. (2001)	demand
Yu et al. (2001)	demand, order
Yu et al. (2002)	demand, order

The value of information sharing depends on several conditions. For example, Simchi-Levi and Zhao's (2003) showed that demand sharing has no significant benefits for a manufacturer under tight capacity. Lee, So and Tang (2000) found that demand information sharing has more value if demand is highly correlated over time, highly variable, or the lead-time is long.

The product's characteristics also affect the value of different kinds of information. Sharing forecasts of demand of products that have high demand variability brings significant benefits (Angulo, Nachtmann et al. 2004). The relationship between trading partners also influences the selection of the type of shared information. For example, sharing production schedules with part suppliers can reduce part inventories without risking stock-outs. Sharing shipping information with logistics agents can improve customer service levels. Information sharing arrangements are dictated by circumstances (Mentzer, Min et al. 2000). Most of the existing studies only analyse the sharing of production information, but other information for example, market and consumer information can be important (Mentzer 2004). Lee and Whang (2000) showed that sharing market knowledge can improve promotion planning. Sharing information and close coordination between retailers and manufacturers may facilitate developing new products.

The previous studies have analysed a number of types of shared information however there is still a critical question that needs more investigation i.e. what information should be shared with supply chain partners that give most benefits?

SHOULD INFORMATION BE CENSORED?

An attribute of information is its timeliness. Delayed transmission of information exacerbates the effects of volatility afflicting the upstream level of a supply chain (Forrester 1958). Chen (1999) examines the impact of delay of information transmission (also called information lead-times) between supply chain stages. Reducing lags in the transfer of information from downstream is highly beneficial. Bourland et al. (1996) found that timely demand information affects suppliers' inventory control policy and that sharing demand information daily can decrease suppliers' expected inventory cost especially when demand variability is high.

Another attribute of information is the level of detail or completeness of information. If the information is transmitted every week, for example, there would be a question whether data should be provided on daily basis or aggregated per week. It is obvious that aggregate data has different variance than daily data and this could affect the operating decision of companies in a supply chain. There is possibility that some companies might not want to share their detail data with partners, fearing that the data could leak to their competitors. As a result, those companies may only provide aggregated data. For example, they might share demand data on category level of products but not provide detail of size, colour or other product attributes. On the other hand, suppliers might need those detailed information in order to predict the various trends of each type of product. Furthermore, providing comprehensive data might weaken a company's negotiating position.

HOW THE BENEFITS SHOULD BE DISTRIBUTED?

Numerous studies analyse the value of information sharing in a supply chain and factors that affect the value. The overall objective of information sharing is to achieve efficiency in the whole supply chain. However, it is apparent that different parties obtain different returns from information sharing (see Table 3). Ideally, all members of a supply chain should share the benefits equally but members with monopoly power may obtain most of the benefits. Under intense competitions, savings may flow through to customers.

Table 3: The value of information sharing and its allocation in the literature

Authors	Benefits and allocation
Lau et al (2002)	Inventory reduction
	Not all partners obtain benefits
Simchi-Levi and Zhao(2003)	Manufacturer gain benefits
Mitra and Catterjee (2004)	Only the supplier gain benefits
Waller et al. (1999)	All parties benefit
	Non-sharing partners also gain benefit
Huang and Gangopadhyay (2004)	Not much benefits for retailers
Cachon and Fisher (2000)	Not significant benefits from information sharing
Yu et al. (2001)	Manufacturer gain more benefits
Lee et al (2000)	Only manufacturer benefits
Smaros et al (2003)	Manufacturer gain benefit
Chen et al. (2000)	Reduce but not eliminate the bullwhip effect
Bourland et al (1996)	Supplier gains more benefits

The unbalanced benefits of information sharing can discourage information sharing. Most studies on the value of information sharing suggest that companies who gain most benefits give their trading partners incentives in various forms such as lower wholesale prices, flexible payment terms, etc (Bourland, Powell et al. 1996; Yu, Yan et al. 2001; Mitra and Chatterjee 2004). There are few studies investigating how to align benefits between parties. Raghunathan (2003) suggests that manufacturers offer subsidies to retailers and incorporate the amount of subsidies into calculating the optimal number of retailers. Therefore, there is a strong need for more investigation on how to share the benefits of information sharing amongst partners.

THE IMPLICATION OF INFORMATION SHARING FOR ORGANIZATIONS

Realizing the benefits of information sharing depends on companies' ability to utilize shared information in their business processes. Kulp et al. (2004) did a survey to investigate the impact of information sharing on companies' performance. They found that the highest profit margin companies are not simply exchanging information but they combine it with close collaboration. Lee and Wang (2000) argue that information sharing is only enabler for achieving supply chain efficiency. Gavirneni (2002) showed that the benefits of information sharing can be obtained if companies change their operational policy.

To take full advantages of information sharing, some significant changes in organization need to be implemented once information sharing in place. Companies should move toward collaboration with their partners to achieve common goals of supply chain efficiency that is built based on high level of trust between companies. Lee (2000) argues that collaboration and coordination can be achieved through exchanging decision rights, work and resources. Exchanging decision rights, such as in a VMI program, should not be considered merely to alleviate the bullwhip effects or to simply shift costs and responsibility to other parties, rather it should be noted that other parties are in the best position to accomplish such decisions. Work realignment is redistribution of physical activities amongst members of supply chain and may lead to reduce total supply chain costs. Work realignment can only be effective if information sharing is in place. This work realignment needs a cultural shift in organization to treat supply chain partners as if they are parts of organizations.

Mentzer (2004) further argues that people can impede or facilitate collaboration. Information sharing will not bring significant benefits if people in organization still persist with past behaviours, exemplified by functional silos thinking.

These considerations and the potential benefits suggest the following research questions:

- What are the barriers of implementation of information sharing?
- What are the critical success factors?
- How should information sharing be implemented?

CONCLUSION

This paper has presented a number of existing studies on information sharing in supply chains. Many investigations on the impacts of information sharing have been carried out under different circumstances and assumptions. From the above discussion, the following conclusion can be drawn:

- The value of information sharing varies amongst parties in a supply chain
- Each type of information provides different benefits to supply chains
- The benefits of information sharing is affected several factors such as demand variance, production capacity, etc.

Based on the various issues presented in the literature, this paper proposes a research agenda focusing on resolving how to deploy information sharing. The following major research questions are suggested:

- With whom should information be shared?
- What information should be shared?
- Should information be censored?
- How the benefits should be distributed?
- What are the implications for organizations?

There is strong preliminary evidence that information sharing can bring major benefits for supply chains. Improved technologies make information sharing easy. It is timely to reconsider these research questions especially in an environment dominated by globalization, increased consumer expectation and intensified competition.

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