A Characterisation of Information Sharing in Supply Chains

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Abstract

A supply chain typically consists of interrelated members such as raw-material suppliers, manufacturers, distributors, and retailers who have different ranges of private information. Information sharing is a strategy for achieving cohesion of all functions amongst chain members, so as to provide adequate visibility to enable them make good decisions that can improve the total chain profitability. It is not surprising that many studies in both theoretical and practical orientations have been devoted to emphasising the benefits of information sharing. However, little attention has been given to highlighting a comprehensive characterisation of information sharing in supply chains. This paper provides both the characteristics of research contents and approaches and a simple characterisation of information sharing. Since total visibility is difficult to obtain amongst chain members, the paper also conceptualises incentive mechanisms to motivate them to share relevant information.

Key words: information sharing, supply chain management.

Introduction

Information sharing among chain members provides mutual competitive advantages both in increasing customer values and taking out costs from the supply chain. Those chain members with timely products and higher quality will be able to charge higher prices and increase sales. Several examples from industrial practices show the positive impact of information sharing on supply chain performance. Wal-Mart, a retailing firm, employs on-line information sharing of point-of-sales data including sales and stocking data with its major suppliers. Data tracking of sales enables the suppliers to differentiate popular from slow-moving items and to take

appropriate action either to replenish or to discontinue the goods in the retail stores. The suppliers can reduce inventory costs and improve product availability. As a computer firm, Dell utilises online information sharing to leverage the logistics capability that can create excellent customer service (Schonfeld, 1998). Dell is able not only to satisfy its online purchasers, but also to provide visibility of customer orders to suppliers. Those suppliers are able to see what parts Dell needs today and what parts will be needed in the coming week. As a result, the suppliers can reduce inventory on-hand as well as delivery lead-times.

Benetton, a clothing industry, electronically receives orders and sales information from hundreds of company agents located around the world (Foster, 1993). By tying its logistics and manufacturing systems in with its suppliers and company agents, Benetton can set the best cycle times in the industry and near-perfect customer service levels. It also reduced costs from lost sales and obsolescence. Levi Strauss, another fashion firm, also capitalises on information sharing and computerised fabric cutting to customise a variety of jeans for different customers (Schonfeld, 1998). With the increase in customisation, Levi Strauss can charge premium prices for personally fitted jeans.

Given the important role of information sharing in performance improvements, Lee *et al.* (1997a,b) in their seminal papers initiate the analysis of information sharing in supply chains from the perspective of operations management. A number of related contributions to this topic have appeared. They vary from theoretical and practical orientations to different emphases on decision and information structures. However, little attention has been given to highlighting a comprehensive characterisation of information sharing in supply chains. This paper provides both the characteristics of research approaches and contents and a simple characterisation of information sharing.

Information Defined

Information system literature often views data, information, and knowledge as an interrelated hierarchy (Tuomi, 2000). Meaning attached to data leads to information and information can be used to create knowledge. Data form a representation of the real world such as events, phenomena, attributes, names, and so forth. They may be presented as alphas, numerics, alphanumerics, or pictures that

exist on paper and in databases. Data become information when people acquire them in the course of their daily activities and assign meaning to them through interpretation. Information exists in the collective mind of people. Information becomes knowledge when a person internalises it to a degree that it is available for immediate use for problem solving or explanation.

Knowledge can be classified into several classes. Polanyi (1966) differentiates between tacit and explicit knowledge based on its degree of articulation. Forms of knowledge such as beliefs, intuition, and judgmental abilities that are not easily communicated he calls tacit knowledge. Information which can be seen as communicable forms of knowledge constitute explicit knowledge (Polanyi, 1966). Jensen and Meckling (1992) propose the categories of specific and general knowledge based on the costs of transfer. Specific knowledge is costly to transfer among users. General knowledge is composed of forms of knowledge that are inexpensive to transmit. Both concepts of classifications are important to improve knowledge creation and knowledge sharing.

Although the hierarchy view of knowledge explains how knowledge is created, it does not explain how knowledge can be used to trace the required information to answer questions or make decisions. An interactive view is thus proposed to describe both forward and backward linkages of information (see Figure 1). Each state of data, information and knowledge can be transformed into the subsequent or preceding state. Tacit knowledge that consists of validated theories and understanding can be verbalised to construct information. Information can be formalised to inform required data. Data that represent the real world would direct to observable facts. On the other hand, every organisation needs to scan its environment and operations to capture data. A set of string or indication that gives meaning about the real world is called data (Goldratt, 1990). One needs to know the convention or the rules of encoding to recover information from data. Problems or decisions can be solved only by using information and not using the required data. Similarly, Goldratt (1990) emphasises the fact that information is the answer to the question asked, not the data required to answer the question. Thus information is extracted from data by using conventions or rules of deduction. Finally, information becomes knowledge through testing, validating and codification.

An interactive view of information enables people to define the level of information they need to solve problems or make decisions. Depending on the

decisions, some people can use data to answer the questions, but others need to extract information from the same data to solve their problems. This interactive view also enables people to trace the source of knowledge from the available data, or to specify the required data based on their explicit knowledge.

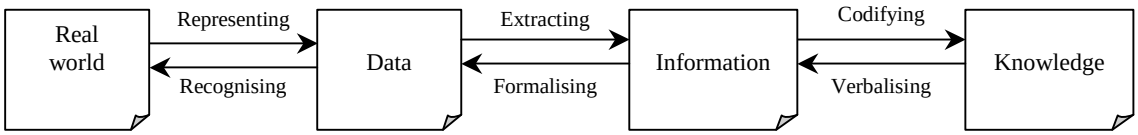

Figure 1. An interactive view of information

An information system is used to collect, process and disseminate information to make it available for decision makers at the right time. Traditionally, an information system deals with transferable data through plain media of communication such as EDI and the internet. The recent advance of information technology offers a rich variety of media such as video conferencing and online decision support systems that enable decision-makers to convert tacit knowledge into explicit knowledge and to share explicit knowledge.

Asymmetric Information

Asymmetric information refers to different players in a supply chain having different states of private information about resources (capacity, inventory status, and funds), various data related costs, the chain operations (e.g., sales, production, delivery schedule, forecasting), performance status, and market conditions. One player has private information that the others do not have to make good decisions. As a result, the supply chain suffers from (i) misunderstanding concerning the mutual efforts of collaboration, (ii) difficulty in dealing with market uncertainty, (iii) sub-optimal decisions, and (iv) opportunistic behaviour.

The chain members easily slip into misunderstanding about the mutual efforts of collaboration because they have different positions in the supply chain and thereby have different aims, strategies, and roles. Unless they share the sensitive information required to develop mutual goals and strategies, they become involved in conflict about conflicting objectives, decision rights, and responsibilities. This conflict may lead to unproductive allocation of resources, and redundant or overlapping activities.

Differences in information about market conditions among the players lead to difficulty in dealing with market uncertainty. The retailing companies, for example, have better access to customer demands compared to other upstream players. They often accumulate demand information and transfer data in large batches to the immediate upstream members. Data may include ordering and customer needs. Ordering data is important to determine demand forecasting and to plan when, how much, and where to deliver the products. Data about customer must be considered when developing new products. As the downstream players have the ability to distort demand conditions, the upstream players may experience larger variance of customer demand. Besides a lack of visibility of end customer demand, other factors that contribute to increased demand swings include promotions and pricing to end customers and trade deals among the chain members (Lee *et al.*, 1997b). Figure 2 depicts the logic tree which explains why inadequate visibility of customer demands leads to lower profitability. A large error in forecasting leads to frequent updates of schedules, difficulty in managing genuine capacity scarcity, long lead-times, the maintaining speculative inventory, and increased risk of product obsolescence. Furthermore, lack of information about customer needs makes it difficult to design the products which are seen as being the most desirable, especially for innovative goods. Outdated products due to long lead-times lead to lower prices (i.e., mark-downs) and write-offs due to obsolescence.

Sub-optimal decisions occur when the chain members cannot resolve various trade-offs in decision-making because the chain member does not have the required information to make operational decisions that can ensure that products flow properly to end customers (Simchi-Levi *et al.*, 1999). If there is no information sharing, then decisions are made based on the best estimation of available data. Such decisions can be biased and prevent the individual chain member from attaining the optimal solution. For example, the manufacturer often delivers large batches of products to minimise transportation costs, but this upsets on-time delivery performance because there is no visibility about what end customers want and the level of inventory is available at the retail stores. Without global visibility, the players cannot make good decisions that can improve the overall chain performance.

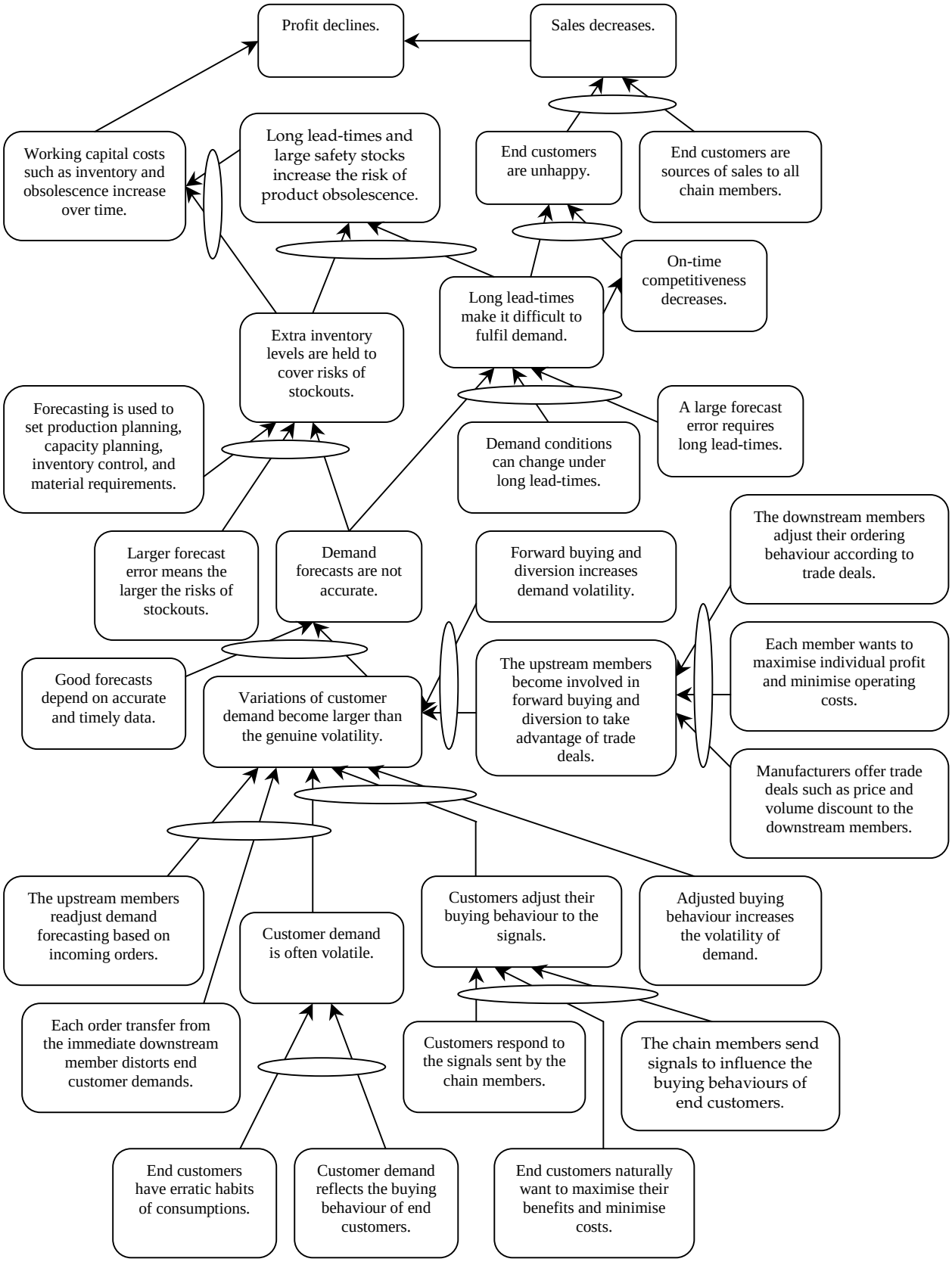

Figure 2. The logic tree of why inadequate visibility of sales data leads to lower profit (The tree is read IF 'tail of arrow' THEN 'head of arrow'. The oval means AND)

Opportunistic behaviour stems from the self-interest of the players by which each of them attempts to maximise individual advantages and avoid costs. The entire supply chain is vulnerable to opportunism. Asymmetric information makes it possible for the players to hide private information and to be guilty of shirking such as reducing the effort levels. The potential for opportunism can occur prior to, or after, the contract (Molho, 1997). Pre-contractual opportunism is known as adverse selection. This includes misrepresentation or hiding truthful information about capability, resource, and demand conditions that need to be shared before the contract is signed. Moral hazards such as the provision of misleading information about performance status, lowering service level efforts, and a minimum level of resource allocation commitment occur after the signing of the contract. The chain members need to identify and address both types of opportunism.

Information Sharing

An agreement for information sharing is a commitment to mitigate asymmetric information amongst chain members through providing access to private information. Of course, willingness to share information depends on trust and the economic value of the information. Once the chain members are willing to share information, they need to redesign their information structure to be able to gather and transfer private information to be available for making good decisions.

An information structure refers to a description of the range of each firm's private information (who knows what) and dissemination of information among the members. Given the structure of information, the chain members need to devise the optimal strategies for decision-making. Instead, the chain members need to redesign their information sharing systems so that they can provide the required information to the decision makers. Information sharing facilitates data collection, documentation, and the storing, retrieving, and transferring of private information. It depends on the level of decision structure that requires specific data. The decision structure consists of decisions that need to be taken at the levels of operations, planning, and strategy. Depending on the decision structure, the information structure ranges from ordering information sharing, partial information sharing, and strategic information sharing. Ordering information sharing means that the chain members communicate through ordering data for transactions. Partial information sharing allows selected data, such

as sales and inventory data, to be available for the upstream members of the supply chain for the better planning and controlling of activities. Visibility of strategic information may include sharing strategic information such as category management, market research and costs-related data. This enables the chain members to carry out strategic planning and enhance productivity. The chain members who become involved in strategic visibility have to protect carefully the confidentiality of proprietary data (Lee and Whang, 2000).

In addition to the decision and information structures, the chain members also need to identify and quantify the benefits of information sharing. Information sharing seems to require immediate costs - but the participating members need to spend additional time also to be able to capture and distribute the benefits of information sharing. The benefits of information sharing need to be factual in assisting in the making of good decisions that create competitive advantages. The benefits can be measured in both non-monetary and monetary terms. There are four main benefits of information sharing in supply chains: (i) achieving contractual clarity, (ii) dealing with market uncertainty, (iii) facilitating supply chain coordination, and (iv) reducing opportunism. Figure 3 shows how information sharing may result in several benefits. The following paragraphs discuss the four benefits of information sharing.

First, information sharing helps in achieving contractual clarity. A contract is an agreement among the chain members in a specific market that specifies objectives, areas of decision domain, the level of information sharing which is required, performance measures, and transfer payments. The general conditions of a contract can be divided into four phases: initialising period, forward-looking planning, execution, and review. A contract is initiated among the players during the start-up period. Then, the players devise the tactical planning in order to match resources (i.e., capacity, capability, and inventory) with future market requirements. In the execution phase, the players actually carry out the processes based on the tactical plans. The execution of processes results in process outcomes (i.e., on-time delivery, capacity utilisation, inventory turn-over, and improved transportation contracts) and customer outcomes (i.e., improved customer service and satisfaction). Customer outcomes lead to financial outcomes such as sales and cash flow. Finally, the contract review is the time period needed to evaluate the contract and to decide whether it should be modified, extended, or terminated.

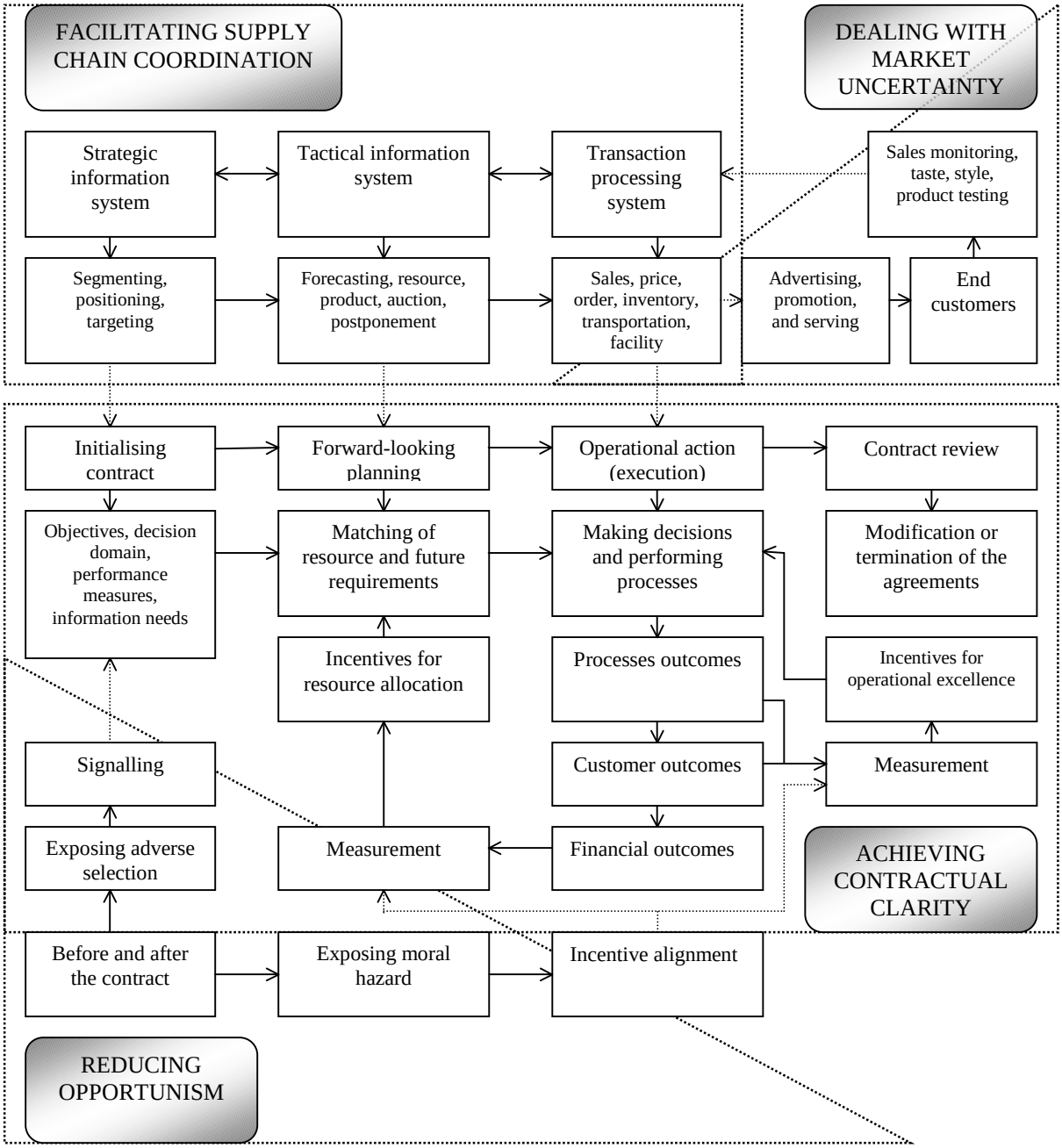

Figure 3. A comprehensive view of information sharing benefits

There are two activities that determine how well the chain members achieve the business objectives. First, the tactical planning activity determines how well the chain members allocate required resources to the processes. This planning uses relevant information of customer demand to synchronise resources and processes. Second, the execution activity determines how well the chain members utilise the resources. Assessing both activities can be used as a basis to distribute the benefits

and the burdens of the contract. Resource allocation and utilisation incur working capital and operating costs. Measures of process outcomes and customer performance can be used for assessing how well the chain members do their jobs. Moreover, the measurement of financial outcomes can be used to reward the appropriate allocation of resources. Information sharing makes it possible to optimise resource allocation, to measure the overall performance, and to distribute the burdens and the benefits by using appropriate incentive schemes.

Second, information sharing of customer data helps the chain members to respond quickly to the uncertainties of the marketplace. The retailer, for example, can provide sales and customer data to the manufacturer. The manufacturer can use the shared data to understand the behaviour of end customers and the phenomena of demand amplifications. The volatility of demand can be segregated into genuine fluctuations that reflect the customer patterns of consumptions, and induced fluctuations due to the signals of local policies sent to end customers. By identifying the possible causes of demand fluctuations, the manufacturer can devise ways to eliminate the causes. Moreover, sharing sales data can also help to increase the accuracy of sales forecasting, which is important for keeping inventory low without risking the loss of sales due to lack of product availability.

The third benefit of information sharing is to facilitate supply chain coordination among the chain members. The aim is to improve the order fulfilment process. The types of shared information include inventory status, order status, sales, production schedules, and other related cost data (Lee and Whang, 2000). Using shared information for the order fulfilment process aims at enhancing sales and at the same time reducing total costs, improving quality, and shortening cycle times. For these reasons, information sharing should enable the chain members to resolve cost tradeoffs among decisional alternatives of batch ordering, facility, inventory, and transportation (Simchi-Levi *et al.*, 1999).

Fourth, reducing opportunistic behaviours refers to the use of shared information to eliminate self-optimising decisions both before and after the contract. The problems of adverse selection or misrepresentation of partner capabilities can be resolved by signalling. On the other hand, incentive alignment is required to mitigate moral hazards or cheating after the signing of the contract. The starting point is an assessment of the impact of opportunistic behaviour on logistics performance. Next, the specific ways of information sharing in which performance can be improved must

be established. Signalling, as one way of information sharing, may take the forms of reputation, prior capabilities, or faithfulness to share sensitive data-related costs. Incentive alignment can be created based on price commitment and premiums, risk sharing, and performance standards. Information sharing system must be developed to facilitate direct monitoring and delivery of incentives to encourage performance improvement as well as to mitigate manipulation. Finally, each available mechanism should be subject to the cost-benefit analysis involving its likely effect on better performance and the cost of deployment.

Furthermore, a chain member with superior information wants to ensure economic benefits from information sharing, given the positive impact of shared information on performance. A supply chain should jointly design incentives for information sharing that link to performance metrics. All the benefits of improvements in the performance must be distributed fairly according to each member's contribution. If information sharing provides equal distribution of the benefits, then the chain member with superior information may not wish to join the supply chain. The issue of distribution of gains as a result of information sharing among chain members is an area of active research (Lee and Whang, 2000).

To illustrate, the manufacturer delegates works to the retailer to deliver his products to end customers. The retailer's actions (e.g., service level in product availability), which are not observable by the manufacturer, will affect the revenues derived from selling the products. The retailer who has superior information about demand conditions can take advantage of this information gap between the manufacturer and himself to enhance his own benefits by shirking (i.e., lowering the service level) at the cost of the manufacturer. Monitoring to control the retailer's actions is often costly and, in most cases, ineffective. The problem of the manufacturer is to design appropriate incentives to induce the retailer to reveal private information. One way to solve this problem is to tie the retailer's actions - such as better customer service and appropriate retail pricing - to the improved sales. The resulting savings can be shared between the manufacturer and the retailer. The contract between the manufacturer and the retailer includes the investment in the information sharing system required to monitor the retailer's compliance with the performance standard (Desiraju and Moorthy, 1997). Access to point of sales data enables the manufacturer to deliver incentives and to direct the retailer in improving the service level.

The characteristics of information sharing noted above depend on an information system that helps the chain members to acquire, store, and process private information and make it available to a wider set of users in a timely manner. Although information sharing brings enormous benefits, not all information can be transferred. For example, demand information can be separated into local knowledge that cannot be communicated (such as intuition for local market conditions) and data that can be transferred (such as past sales and inventory levels). Retailers receive a multi-dimensional signal about consumer demand including sales information, prices, location specifics, and other qualitative information. This is true especially for innovative products where demand conditions vary following the stages of the products' life cycle. In this case, manufacturers need to receive market signals consisting of less reliable demand data before the season and more reliable demand data during the early season in order to be able to make production and delivery decisions. However, many information systems transmit only a one-dimensional signal such as sales and stocking data, and much qualitative information is lost in such transmission. Furthermore, the data transferred may not be as precise as the retailers' information if the retailers are unwilling to communicate full information. As a result, the manufacturer may not be able to interpret the data as well as the retailers do.

Since a large proportion of required information is stored in the memory of the player who has better access to the source of information, embracing multiple decision-making authorities (who decides what, also referred to as decision rights) is more productive than trying to neglect them. Jensen and Meckling (1992) suggest two alternative designs to improve the decision-making process: either bring information closer to the decision makers, or allocate decision rights to the chain member who has better access to information. Cohen *et al.* (1972) also propose reversing the process of traditional decision-making: communicating the decision problems to the member who has the relevant information, instead of trying to obtain relevant information for the original decision makers. Combining the choices of decision right allocation and information sharing system provides a comprehensive structure of bringing together decisions and relevant information.

For instance, the chain members consisting of a supplier and a retailer have to design a joint decision-making team that consists of the person who makes the stocking quantity decisions for each store, and the information that is available to each local decision maker. The retailer owns and controls how many items to stock, but the

supplier sets the wholesale price. The retailer takes the price and determines the best stocking levels to maximise his profits. In practice, this concept is known as a Retailer Managed Inventory (RMI). On the contrary, a Vendor Managed Inventory (VMI) gives ownership and control of inventories to the supplier (Holmstorm, 1998). The supplier decides the inventory level at the retail stores based on shared information, such as demand and inventory status, obtained from the retailer. The retailer determines wholesale prices that are normally set to be a fixed margin for each unit sold in his store.

Research on Information Sharing

Research on information sharing can be divided into two parts: contents and approaches. The content of information sharing necessary to demonstrate the existence of asymmetric information, causes of unproductive situation, and how to capture and redistribute the values of information sharing is generally similar. Nevertheless, this paper proposes that the research content of information sharing can be categorised into six interrelated items as follows: (i) the state of nature shows the sources of uncertainty and ambiguity that need to be addressed; (ii) the decision structure, which comprises the supply chain decision processes (i.e., inventory decisions, transportation, capacity, and facility) and the decision authority (who decides what); (iii) the information structure which entails the types of relevant information, the description of data sharing role (provider, recipient, broker, and vendor), the sharing arrangement (formal contract, mandate to share or distribute, and voluntary agreement), the exchange method (direct or third party), and the exchange schedule (on demand, on schedule, and as needed); and (iv) the values of information sharing – explaining or detailing of the benefits, quantification of the benefits, the recipient of the benefits, and schemes of gain sharing including incentives or pricing for information sharing.

The research approaches can be theoretical modelling (i.e., explaining the phenomena) and practical orientations (i.e., applying the principles of information sharing in real problem solving) (Moorthy, 1993). Table 1 shows the selected contributors and the research contents and approaches, to cite a few. From the current publications, it appears that little attention is given to characterising information sharing in supply chains.

Table 1. Selected contributors and the research contents and approaches

No.	Selected contributors	Research contents				Research approaches
		The state of nature	Decision structure	Information structure	Values of information sharing	
1.	Lee, Padmanabhan, Whang (1997a)	Demand, capacity, lead-time	Demand signal processing, the rationing game, order batching, and price variations.	Retailers possess sales data, manufacturers have capacity, lead-time, and wholesale pricing. The traditional method uses orders. The proposed method employs access POS data, EDI, and shared capacity and supply data.	Reduced demand variance, lower transportation costs, improved utilisation of capacity. No mechanism of incentive is provided.	Mathematical models of supply chains to understand the causes and managerial implications of the bullwhip effect.
2.	Iyer and Bergen (1997)	Demand uncertainty at time zero and during the season.	Stocking decisions of both parties - the supplier and the retailer.	The retailer captures the extensive POS data. The retailer provides POS data to the manufacturer.	Lower inventory and lead-times. Sharing POS provides unequal benefits for both parties. Proposed initiatives include commitments using service level, commitments regarding the wholesale price, and volume commitments across products.	Mathematical models to explain who wins and who loses both before and after quick response.
3.	Anand and Mendelson (1997)	Uncertain demand in multiple horizontal markets.	The use of joint information structure and decision rights to improve the supplier's order allocation.	Headquarters have general knowledge of demand information across the horizontal markets. The retailers have specific knowledge of demand information.	Efficient stocking decision when specific knowledge of market is combined with the power to make decisions using that knowledge. The use of transfer price to mitigate incentive problems.	A theoretical framework for analysing the impact of alternative coordination structure on firm performance.
4.	Lee and Whang (1999)	Stationary demand	A serial multi-echelon inventory system. Each site manager is accountable for a single inventory system. The properties of performance scheme: the cost conservation property, incentive compatibility, and informational decentralisability,	A decentralised information structure has access to the site inventory status only. The distribution of final demands is commonly known to site managers.	Ordering decisions taken by site managers can maximise the overall objective. Incentive is based on re-alignment of contractual relationships.	Employing a multi-echelon inventory system to explain the performance scheme.
5.	Cachon and Fisher (2000)	Stationary stochastic consumer demand.	Inventory models include reorder point policies and updated order decisions. The supplier exploits data for better supplier replenishment and better allocation to the retailers.	The traditional information exchange uses orders. With IT, the retailer can share demand and inventory data.	Lower costs, shorter lead-times, and smaller batch sizes.	Mathematical models to explain differences of information sharing values between with and without exploiting shared demand information.

A Characterisation of Information Sharing

Characterising information sharing requires consideration of the locations of information and decision rights (Cohen *et al.*, 1972; Jensen and Meckling, 1992; Anand and Mendelson, 1997). Information sharing brings the relevant information system from the location of information to the decision makers. A decision right shows the authority for making particular decisions. The collocation of information and decision rights enables decision makers to mitigate uncertainties that reflect customer buying behaviour and the interrelated operations across the supply chain.

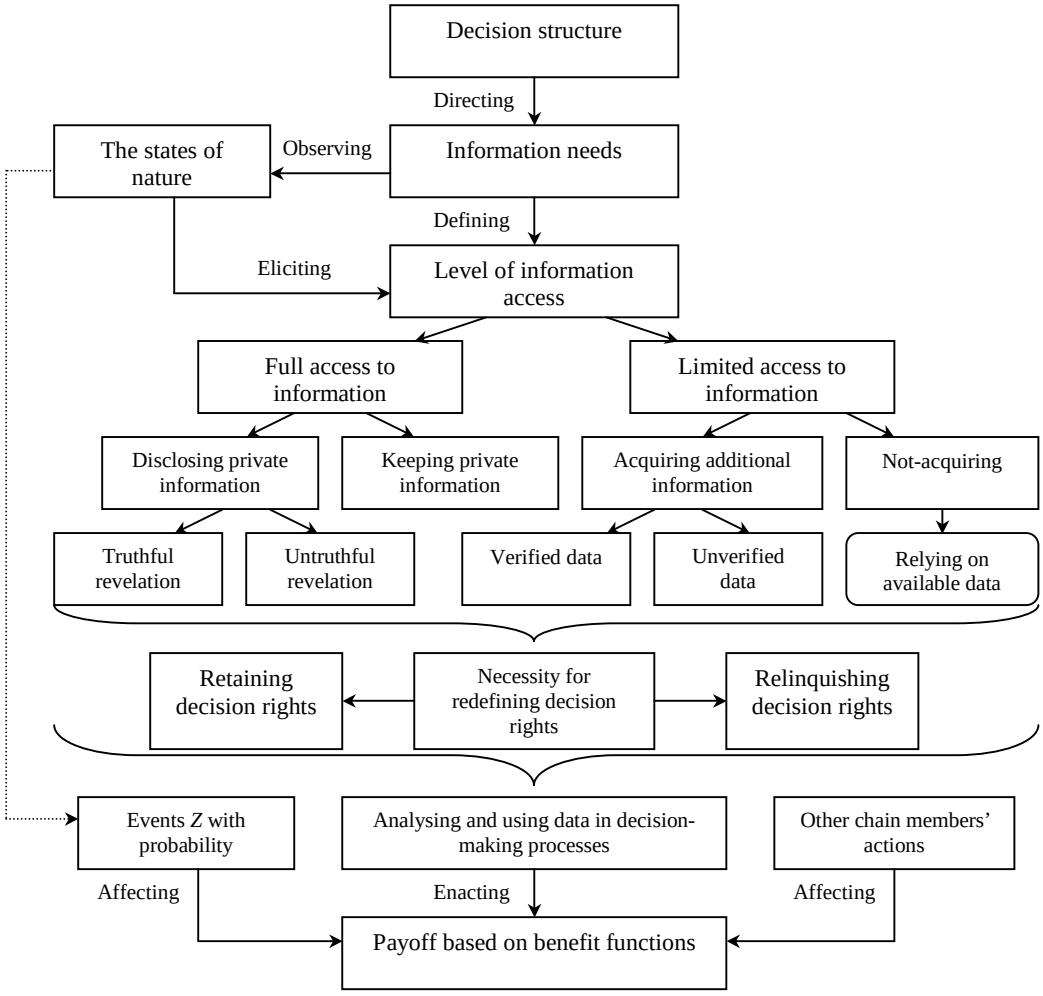

Figure 4. A simple framework for analysing the choices of information sharing

Figure 4 shows a simple framework that considers both information sharing and decision rights. The framework provides a means of analysing various choices of sharing information. The importance of information depends on the information needs of the decision structure. A player needs to decide what private information he needs to disclose and what additional information he needs to acquire in order to make a

better decision. The players also need to analyse whether it is better to retain decision rights, or relinquish these to the partner so that the recipient of authority can use his specific and general knowledge to make better decisions.

Based on the locations of information and decision rights, there are several alternative models that can be analysed in designing an information sharing system (see Table 2 for a complete list of choices). For example, the traditional model is a competitive supply chain (i.e., keeping private information, not acquiring additional information, and retaining decision rights). After analysing available models, a chain member can choose a better model that provides a higher payoff.

Table 2. The possible choices of information sharing structure

	Necessity for redefining decision rights			
	Retaining decision rights		Redefining decision rights	
	No disclosure of private information	Disclosure of private information	No disclosure of private information	Disclosure of private information
No acquisition of information	Competitive Supply Chain	Disclosure Agreement	Arm-length Agreement	Principal-agent Agreement
Acquisition of information	Acquisition Agreement	Communicative Agreement	Principal-agent Agreement	Collaborative Supply Chain

A general process which outlines how the framework can be used to analyse information sharing is as follows. First, there are *n* players in a vertical supply chain. A chain member possesses a decision structure that requires relevant information. Second, information needs direct the player to observe the states of nature. The states of nature can be in the form of demand conditions, capacity, lead-times, and costs that can be different for each firm. Each firm receives a private signal with information about the true state of nature. They may have access to noisy signals about demand conditions or they may know their own costs exactly but not the costs of other players. Data collected can be segregated into private and external components. The private component consists of information elicited personally from the source of information. The external component consists of information that is not personally known by the player. Third, private information can be exchanged. The player decides whether to reveal his private information or to acquire additional information from other members. The player may disclose his private information truthfully or untruthfully - as well as partially or completely - to other players. Information can be required if the existence, the location, and the means of retrieving such information are known by the player. The acquisition process may be simple - such as one player

asking for, and receiving, the desired information from another - or may involve a series of transactions. Additional information can be a source of competitive advantage, but if it is not used, then the player will, inevitably, make errors. Fourth, players can cooperatively, or non-cooperatively, make decisions so as to maximise the payoff or expected profits conditional on the available private and revealed information.

Towards A Win-Win Situation

Multiple parties with different private information involve both acquisition and disclosure of private information to accelerate orders, goods, and payments to end customers. The collection, dissemination, and use of shared information should be combined with the applications of logistics postponement, dematerialisation, resource exchange, leveraged shipments, and clicks-and-mortar to provide better payoffs (Lee and Whang, 2001). However, the collection, dissemination, and use of information may lead to differences in benefits and burdens between the receiving party and the disclosing party. If the benefits and the burdens are inequitable, then the members are tempted to distort shared information. Unreliable information results in lower overall performance and thereby both parties cannot capture the potential mutual benefits. Therefore, how to measure the benefits and burdens and associated mechanisms for fair compensation become a critical issue in information sharing.

One way to solve the inequitable benefits and burdens of information sharing is to recognise externalities surrounding the processes of collection, dissemination, and use of shared information. Both positive and negative externalities can occur when the independent actions of a member unintentionally spill over onto the others. Positive externalities provide benefits in the form of lower inventory, reduced costs, and lower price. Negative externalities include an increase in technology investment, inventory costs and a higher transfer price. The participating members can negotiate for a charge in resource allocation that makes everyone better off at the same time. The principle is to increase individual responsibility for attaining better overall performance. In line with this effort, Iyer and Bergen (1997) propose the use of service levels, volume discount, and wholesale price to equalise the benefits of information sharing. Lee and Whang (1999) also introduce performance schemes such

as transfer pricing, consignment, and additional backlog penalty that help individual members to share inventory costs.

A number of mechanisms are available to provide decision makers with incentives to consider the external costs and benefits of information sharing. When parties are independent decision makers (i.e., a self-interest party), rules and procedures such as side payments, subsidies, penalties, auctions, and willingness to pay for information sharing can be used. When parties have mutual interests, incentive schemes such as productive-behaviour-based incentive, pay-for-performance, and equitable compensation can be employed (Simatupang and Sridharan, 2001).

Concluding Remarks

Uncertainties that arise from demand conditions, interdependent supply chain operations, and the existence of opportunism motivate the chain members to exploit information sharing. The main benefits of information sharing in supply chains include: achieving contractual clarity, dealing effectively with market uncertainty, facilitating supply chain coordination, and reducing opportunism. This paper provides the characteristics of information sharing in terms of both research contents and approaches. The paper also characterises general information sharing and proposes conceptual mechanisms to motivate the participating members to share their private information.

References

Anand, Krishnan S., Mendelson, Haim, "Information and organisation for horizontal multimarket coordination", *Management Science*, Vol. 43, No. 12, 1997, pp. 1609-1627.

Cachon, Gerard P., Fisher, Marshall, "Supply chain inventory management and the value of shared information", *Management Science*, Vol. 46, No. 8, 2000, pp. 1032-1048.

Cohen, M.D., March, J.G., Olson, J.P., "A garbage can model of organizational choice", *Administrative Science Quarterly*, Vol. 17, No. 1, 1972, pp. 1-25.

Desiraju, Ramarao, Moorthy, Sridhar, "Managing a distribution channel under asymmetric information with performance requirements", *Management Science*, Vol. 43, No. 12, 1997, pp. 1628-1644.

Foster, Thomas A., "Global logistics Benetton style", *Distribution*, Vol. 92, No. 10, 1993, pp. 62-64.

Goldratt, Elihayu M., *The Haystack Syndrome*, North River Press, Croton-on-Hudson, NY, 1990.

Holmstorm, Jan, "Implementing vendor managed inventory the efficient way: A case study of partnership in the supply chain", *Production and Inventory Management Journal*, Vol. 39, No. 3, 1998, pp. 1-5.

Iyer, Ananth V., Bergen, Mark E., "Quick response in manufacturer-retailer channels", *Management Science*, Vol. 43, No. 4, 1997, pp. 559-570.

Jensen, Michael C., Meckling, William H., "Specific and general knowledge, and organizational structure", in Werin, Lars, Wijkander, Hans, (Eds.), *Contract Economics*, Basil Blackwell, Cambridge, MA, 1992, pp. 251-274.

Lee, Hau L., Padmanabhan, V., Whang, Seungjin, "Information distortion in a supply chain: The bullwhip effect", *Management Science*, Vol. 43, No. 4, 1997a, pp. 546-558.

Lee, Hau L., Padmanabhan, V., Whang, Seungjin, "The bullwhip effect in supply chains", *Sloan Management Review*, Vol. 38, No. 3, 1997b, pp. 93-102.

Lee, Hau L., Whang, Seungjin, "Decentralized multi-echelon supply chains: Incentives and information", *Management Science*, Vol. 45, No. 5 (1999), pp. 633-640.

Lee, Hau L., Whang, Seungjin , "Information sharing in supply chain", *International Journal of Technology Management*, Vol. 20, Nos. 3/4, 2000, pp. 373-387.

Lee, Hau L., Whang, Seungjin, "Winning the last mile of e-commerce", *Sloan Management Review*, Vol. 42, No. 4, 2001, pp. 54-62.

Polanyi, M., *The Tacit Dimension*, Anchor, New York, 1967.

Molho, I., *The Economics of Information: Lying and Cheating in Markets and Organizations*, Blackwell, Oxford, 1997.

Moorthy, K. Sridhar, "Theoretical modelling in marketing", *Journal of Marketing*, Vol. 52, No. 2, 1993, pp. 92-106.

Schonfeld, Erick, "The customized, digitised, have-it-your-way economy", *Fortune*, Vol. 138, No. 6, 28 September 1998, pp. 114-124.

Simatupang, Togar M., Sridharan, R., "The collaborative supply chain: A scheme for information sharing and incentive alignment", *Research Manuscript*, Massey University, 2001.

Simchi-Levi, David, Kaminsky, Philip, Simchi-Levi, Edith, *Designing and Managing the Supply Chain: Concepts, Strategies, and Cases*, McGraw-Hill, London, 1999.

Tuomi, Ilkka, "Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory", *Journal of Management Information Systems*, Vol. 16, No. 3, 2000, pp. 103-117.