Utility Value and Fairness Consideration for Information Sharing in a Supply Chain

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Abstract.

The importance of information sharing (IS) between an enterprise and its customers or cooperating companies has long been recognized in supply chain (SC) research. Many previous studies revealed that IS could play an important role in eliminating inefficiencies caused by the bullwhip effect. However, since most of them studied IS in a macroscopic way from the viewpoint of no/partial/full IS, they do not have great practical value when applied to the implementation of a specific SC. The objective of this study is to suggest a practical guideline for IS in a specific SC by promoting the needs for IS with technical verification using simulation and value analysis within the concept of profit sharing.

1 Introduction

Various parties in a supply chain (SC) generate information through a number of processes. As each party either provides or receives the information on behalf of their needs, an information chain is formed. Information sharing (IS) in SC not only affects the performance of each entity but also of the entire SC. IS improves SC competitiveness by reducing inventories and tardy deliveries and diminishing lead time between enterprises.

IS in SC has been investigated in two aspects: technological and strategic studies [1]. Although there has been a rapid progress in the former perspective through commercial solutions achieved by software developers, few studies have concentrated on IS and the reason why such information should be shared in terms of

the latter aspect. The three fundamental reasons behind this lack of progress, despite the widespread recognition of the necessity for IS, are the variety of information depending on different industries, the absence of incentives provided for IS, and the differences of strategic standpoint among the enterprises [2].

The primary purpose of this study is to suggest a practical guideline for IS in a specific SC by promoting the needs for IS with technical verification using simulation and value analysis within the concept of profit sharing. In the second part of our study, we briefly review the incentive scheme on profit sharing among the parties in an SC. By a detailed examination of the specific profits and utility values gained by the IS, our approach is expected to help enterprises to generate strategic plans toward IS in their SC.

2 Literature Review

2.1 Information Sharing (IS) in a Supply Chain (SC)

Previous studies with regard to IS in SC may be briefly divided into two classes: mathematical modeling and survey analysis. Gaonkar and Viswanadham inferred the profits gained from IS by using a linear programming model [3]. The authors assumed an SC based on long-term agreement and classified the IS scenario under certain circumstances into two extreme groups: no IS and complete IS. They were assumed to be based on make-to-stock and make-to-order (MTO), respectively, and the performances of both cases were compared according to their cost. Gaonkar and Viswanadham's study determined the effectiveness of IS in SC and has been extended to prove how the sharing of demand plan affects inventory and lead time in SC by simulation analysis. A number of similar studies extended the IS scenarios into three IS categories: no, partial and full. Narasimhan and Nair's survey research, a representative article among the various survey studies conducted to configure IS in SC, was carried out to test whether IS between retailers and manufacturers affected SC performance [4]. More than 4,500 companies were interviewed for the questionnaire, and the test comprised the following six indexes: market share, return on assets, average selling price, product quality, competitive position and customer service. The study concluded that IS does indeed strengthen SC competitiveness.

However, since most of the aforementioned studies regarded IS in a macroscopic way in terms of no/partial/full IS, they have not had much practical value for the implementation of a specific SC. Thus further study is needed to determine how specific information contributes to SC performance. In addition, most of the previous studies only considered supply side IS, whereas the present study is distinguished by its consideration of both sides of the information flow: the supply side information such as production plan and the demand side information such as demand forecast.

2.2 Profit Distribution Issue regarding Information Sharing (IS)

The problem of profit distribution in IS has come to occupy an important position due to the recent advances in IT technology, since the issue was previously neither recognized nor even technically realizable. "Grove Scheme" is regarded as the

exemplary study in this field [5]. The study primarily investigated the profits gained by different organizations according to their performances, and then resolved the distribution of the aggregated profit by giving differentiated incentives. This mechanism assumed the existence of an independent department to adjust and redistribute the overall profit after all other departments report their individual profits. The system was designed so that any party providing distorted information suffers a loss equivalent to their degree of distortion, thus effectively penalizing and thereby preventing such distortion. Feldmann and Muller extended the "Grove Scheme" idea into SC in order to ensure information fairness [6]. Similar to previous research, the authors assumed a third party called "Supply Chain Management" which does not involve or receive any part of the benefits from the SC and merely distributes the benefits.

However, IS in SC may differ markedly from the single organization case, as the parties are legally independent and the expected profits are not equally and precisely measured according to the position in industry held by each specific party. In addition, the basic premise of the third party existing and redistributing the overall profits is unrealistic. This approach faces several problems, including, for example, who assumes the role of the third party, how to solve the ambiguity in the method of profit distribution, and how to get a unanimous agreement on contributions and opportunity cost reductions.

3 Considering the Utility Value and Fairness

3.1 Information Presumption

In this paper we deal with the specified categories of information which contribute to the utility value of SC, rather than simply testing the effect of IS in general. For this reason information that is shared in SC is examined in the following section according to two factors: the information functions and the information flow directions. We restricted the target of interest to manufacturing companies due to the possible wide variation of information type according to industry position. In order to classify the shared information, the functions of every party in SC are divided into five functions with reference to the SC operation reference (SCOR): plan, source, make, deliver, and return. Next, information types, which are assumed concerning their functions, are filtered according to their potential to affect their SC partners. The presumed information for each function is listed in Table 1.

Purchasing and delivering are the most frequent and visible IS activities with corresponding parties of suppliers and retailers, respectively. On the other hand, information treated in the planning and making functions is provided one-sidedly and potentially shared by manufacturers. We neglected the returning function, since the reverse flow of SC was not a major concern in this study.

3.2 Classifying the Shared Information by Level

The information presumed previously is sometimes shared which affects other parties in SC, but the level of sharing can differ according to their own policies. Prior

to assigning the differences, we now reclassify the types of information, as listed in Table 2, according to their flow directions with their generating sources: the supply side information such as production plans and the demand side information such as demand forecast.

Table 1. Presumptions of information shared according to the functions

Functions	Information Presumed
Plan	demand forecasting, launch of new product, current sales figures, phase out of product, promotions
Source	raw material, raw materials on stock, supplier's profile, production plans, purchase plans, purchased list, supplier's goods, supplier's inventory, distribution center, manufacturing plant, delivering vehicles, transportation plans
Make	production plans, manufacturing progress, manufacturing process, bill of material, raw materials, subassemblies, goods on stock, replenishment plans, capacity available
Deliver	customer profile, customer's inventory, sales plan, customer sale, status of orders, customer's credit, contract, goods, distribution center, manufacturing plans, delivering vehicle, transportation plans, delivery difficulties

Table 2. Presumptions of information shared according to the functions

Directions	Supply Side Information		Demand Side Information
Generating Sources	Supplier/manufacturer	Manufacturer	Manufacturer/retailer
Information Flow	supplier ↔ manufacturer		manufacturer ↔ retailer
Details of Information	raw material raw material inventory supplier's profile production plans purchase plans purchased list supplier's goods supplier's inventory distribution center manufacturing plant transportation plans	capacity available demand forecasting production plans manufacturing progress manufacturing process bill of material raw materials on stock subassemblies on stock goods on stock replenishment plans delivery difficulties	customer profile goods on stock demand forecast current sales figures status of orders customer's credit contract launch of new product phase out of product manufacturing plant promotions

Now we classify the level by applying the classifications suggested in Nienhaus et al's survey report [7]. Concerning the demand side information, the importance of demand forecasting and new product launch is relatively high. Concerning the supply side information, delivery difficulties and order status are rather important. We modified each survey result into three levels, as shown in Table 3.

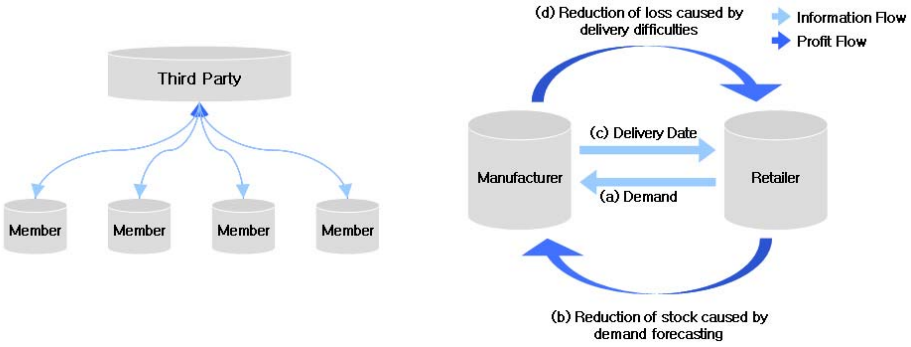
Table 3. Setting the level of information sharing (IS)

Directions	Level	IS
Demand side	Level 1	demand forecasting, launch of new product
	Level 2	Level 1 + current sales figures, phase out of product
	Level 3	Level 2 + goods on stock, production plans, promotions
Supply side	Level 1	delivery difficulties, status of orders
	Level 2	Level 1 + capacity available
	Level 3	Level 2 + goods on stock, production plans

3.3 Considering the Fairness in Information Sharing (IS)

We briefly review the incentive scheme on profit sharing among the parties in an SC. As noted above, however, previous studies faced three problems: unrealistic assumptions on the third parties, ambiguity in distributing the profits, and unanimous agreement on contributions and opportunity for cost reductions.

In our approach, two flow directions in information and profit generation are taken into account in order to describe both manufacturers' and retailers' gains in the form of stock reduction and opportunity cost reduction by introducing a sudden delay of delivery, as depicted in Fig. 1. Since profits cannot be expected according to their own information, they are required, for their own sake, to consider firstly the profit of their cooperating companies. As a result, incentives to share information are given for both manufacturers and retailers to maximize their returns for long-term relationships.



(i) Traditional approach (ii) Proposed approach

Fig. 1. Proposed approach profit distribution considering fairness in the supply chain (SC)

In the proposed approach, information and profit are mutually provided though twin-side flows. Furthermore, information that decides a company's profit is possessed by the counterpart. For example, as indicated in the figure, when a retailer provides demand information to a manufacturer (a), the latter benefits by stock reduction (b). On the other hand, when the manufacturer sends delivery date to the retailer (c), the latter reduces loss by preventing delivery difficulties (d). Considering that these flows will be repeated between parties having a long-term agreement, they will try to

increase their overall profits through frequent IS since their own profits are determined by their counterparts.

3.4. Simulation Test

This section tests if specific information listed previously has different utility values according to the level, and determines the valid information to be shared. The following assumptions are made for the test:

- Manufacturers have a long-term agreement with their retailers and manufacture their products in an MTO fashion.
- Demand patterns of retailers include internal and external parameters as well.
- Manufacturers have limited capacities. The priorities regarding the capacity assignments are a) production of delayed deliveries, b) production of currently appointed deliveries, c) production of deliveries those are presumed to exceed capacities in the future, and d) replenishment for safety stock, sequentially.
- Suppliers and customers are regarded as infinite in number, and are not considered as variables.
- Performance regarding the IS is measured by the improvements in service level and average stock status.

A simulation test is conducted with regard to three cases when a manufacturer and retailer share the same level of information. The relationship diagram among the information flow entities is shown in Fig. 2.

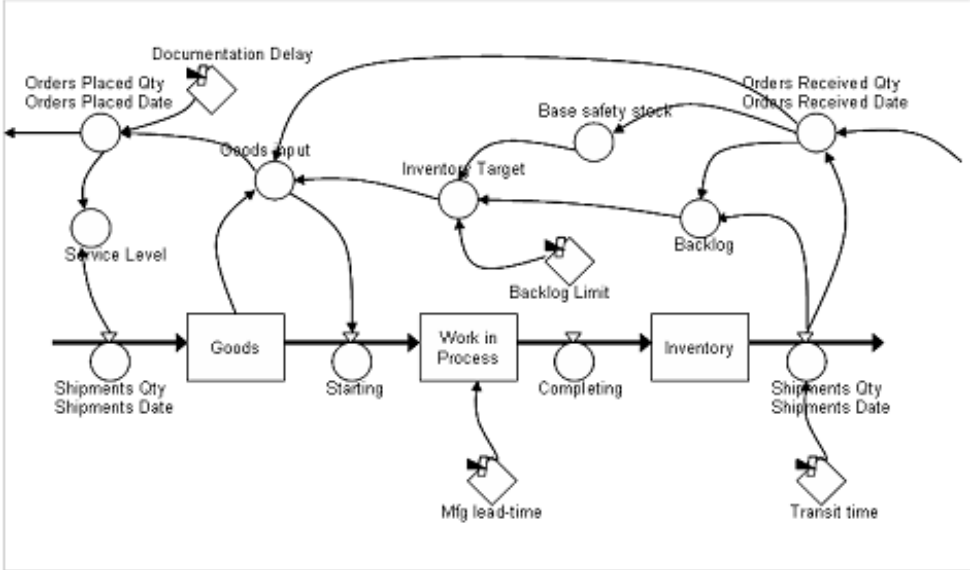


Fig. 2. Relationship diagram among the information flow entities

The test is conducted using the Matlab code. Real data from a company in the beginning of 2005 are applied to generate the customers' orders. Nine product

groups comprising 64 products over a 13-week time horizon are considered with 50 repetitions.

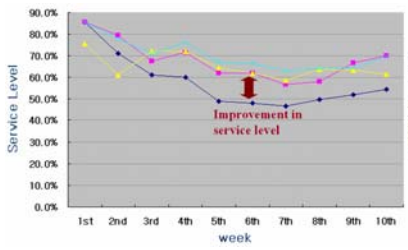


Fig. 3. Variations of service level

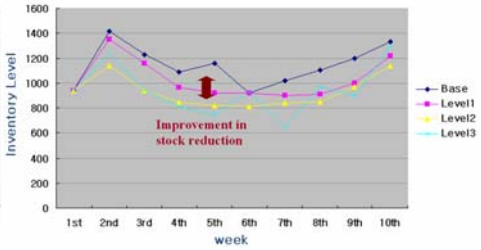


Fig. 4. Variations of inventory level

Fig. 3 indicates that the service level is improved when information is shared. Especially, the effect of sharing Level 1 information is significant. Fig. 4 also depicts that IS reduces the inventory level and the impact of sharing Level 1 information is clearly evident in this case as well. These results show that some of the information makes a significantly higher contribution to performance than others. Considering the variations led by greater IS along with its level, the overall performance continues to increase but the marginal effect for incremental sharing diminishes, as shown in Fig. 5. This finding indicates that if limited information is allowed to be shared then the company should share the information which brings higher marginal effect.

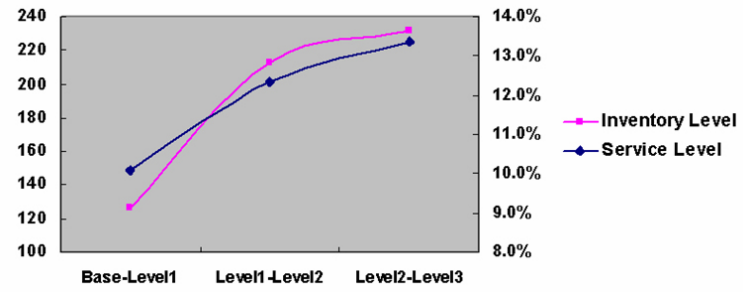


Fig. 5. Incremental improvement through information sharing (IS) by level

Now we examine the profit gained by each party from the above scenarios. The manufacturer reduces the average stock from 0.48 week/year to 0.42 week/year due to the stock information obtained from retailer to alter safety stock and replenish specified stocks that might be in shortage. On the other hand, the profit distributed to the retailer is calculated by the potential reduction in sales loss [volume of goods from manufacturer × improvement in service level], because the benefit might be gained by reducing the loss from delivery difficulties. By anticipating the goods which may be delayed in advance due to the provided information, the retailer

sources the products from other manufacturers or adjusts the delivery date with reference to internal stock. The service level with no IS is 57.6%, whereas IS with Level 1 is 67.7%.

4 Conclusion

Two aspects of IS in SC are discussed. First, specified information, rather than the overall information, is tested by simulation study to determine any significant differences in contribution to SC performance. The types of information are re-classified into 3 levels according to their utility values and the direction of flow by modifying the classifications suggested in several previous survey reports. The experimental results support the assumption that certain types of information should be shared among the SC enterprises to improve the overall performance while considering the IS limitation. Secondly, fairness in sharing the profit gained from the improvement is also discussed. Incentives to share the information were naturally given to both parties which have a long-term agreement in MTO production type in our framework. The distinctiveness was based on the need for the parties to consider their cooperating companies' profits for their own sake. By detailed examination of the specific profits and utility values gained by the IS, our approach is expected to help enterprises generate strategic plans toward IS in their SC. Further study is planned to validate our approach for an increased IS scope such as a greater depth of SC and longer time span.

5 References

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