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# A study on information sharing for supply chains with multiple suppliers

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ABSTRACT

This study considers the coordination of a two-echelon supply chain with multiple suppliers, with which information sharing is essential, since it can often enhance the performance of the supply chain, but may also intensify the competition among members in the chain. In general, information sharing among channel members can improve the efficiency of inventory holding by achieving better quality predictions of demand. Nevertheless, sharing perfect information may often result in the problem of double marginalization; while sharing partial information may result in the problem of distortion between demand and inventory, i.e., the bullwhip effect. This study probes into the impacts of information sharing on inventory reduction and profit gains with consideration of possible promotion activities performed by the retailer, which hinders the suppliers from accurately forecasting the market demand. It is found that, as the demand of successive periods is more correlated, information sharing would have more impact on the reduction of inventory level and total costs of the suppliers, i.e., information sharing is more valuable as the correlation coefficient on successive demand increases.



## 1. Introduction

Effective supply chain management has to consider the profit enhancement of all members in the supply chain by undertaking an appropriate coordination mechanism (Ha & Tong, 2008; Arshinder, Kanda, & Deshmukh, 2009; Li, Ritchken, & Wang, 2009; Proch, Worthmann, & Schlüchtermann, 2017). However, in order to achieve successful supply chain coordination, members have to not only be willing to coordinate their activities and agree on a proper way of redistributing their profits (Disney, Lambrecht, Towill, & Van De Velde, 2008; Cachon & Lariviere, 2005), but also share their information to reduce uncertainty and smooth operations in the supply chain (Ha & Tong, 2008; Mishra, Raghunathan, & Yue, 2007; Costantino, Gravio, Shaban, & Tronci, 2015). Since supply chain coordination has become more complicated due to a more complex business environment and more intense competition, information sharing is thus receiving more attention as an essential part of business practice.

In general, information can be shared vertically, horizontally, and completely. Vertical information sharing indicates that buyers and sellers in the supply chain are partners and mutually share information. Horizontal information sharing refers to the information sharing between buyers and buyers, sellers and sellers, or even competitors and competitors. Finally, complete information sharing, a combination of vertical and horizontal information sharing, can effectively raise the performance of supply chains with partners making efforts to increase the profit of the entire supply chain, and thus maximizing the overall profits (Li, 2002; Gal-Or, Geylani, & Dukes, 2008; Rached, Bahroun, & Campagne, 2015). There are many types of information that can be shared in a supply chain, such as the costs of production and transportation, the demand, and orders. In general, the more information is available, the more room for negotiation and cooperation there is. However, when the information becomes totally transparent, the profits of some members would be squeezed, and thus the problem of double marginalization may occur, in which, as the upstream and the downstream markets are monopolistic, these monopoly companies may determine monopolistic prices to maximize their own profits by limiting their outputs (Iyer, Narasimhan, & Niraj, 2007). However, limiting capacity would result in the reduction of social welfare as well as the profits of both parties. On the other hand, if the information is partially transparent, members in the supply chain may offer incorrect information based on their self-interest, which can result in a distortion between the demand amount and the production quantity (Ganesh, Raghunathan, & Rajendran, 2008; Ketzenberg, Rosenzweig, Marucheck, & Metters, 2007; Gal-Or et al., 2008;

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Mishra et al., 2007; Jeong & Leon, 2012; Bian, Shang, & Zhang, 2016).

In spite of the fact that information sharing is always valuable (Zhou & Benton, 2007; Agrawal, Sengupta, & Shanker, 2009; Gavirneni, 2006; Moinzadeh, 2002; Guo, 2009), in terms of profits, it can be worthless if the cost of information is too high or the value of information is too low (Chu & Lee, 2006; Iyer et al., 2007; Chen & Lee, 2009). Moreover, it is difficult to share complete information in a decentralized supply chain, since most members are independent companies which focus on their own profits (Iyer et al., 2007; Mishra et al., 2007; Guan & Chen, 2015). A decision model was therefore proposed to coordinate and synchronize decentralized members of a two-stage supply chain, with an aim to share central resources and yet keep own information. (Albrecht & Stadtler, 2015). In addition, if suppliers can utilize historical information about orders to forecast the market demand, information sharing may become less critical (Lee, So, & Tang, 2000). However, the retailer would often undertake some activities to increase the demand, such as promotions and markdowns, which hinders the supplier from accurately forecasting the demand based only on the historical order data. Therefore, information sharing would have value in all cases (Gavirneni, 2002; Li, Yan, Wang, & Xia, 2005).

Research on information sharing often focuses on one-to-one or one-to-many supply chains (Ganesh et al., 2008; Ketzenberg et al., 2007; Gal-Or et al., 2008; Agrawal et al., 2009; Gavirneni, 2006; Moinzadeh, 2002), with relatively few discussions of information sharing in many-to-one supply chains. In fact, multiple suppliers can be advantageous, since they can not only reduce the uncertainty about obtaining materials or products for the retailer, but also (1) reduce the wholesale price due to the competition among the suppliers; (2) decrease the uncertainty of the lead time; and (3) avoid the shortage cost due to only one supplier (Arda & Hennet, 2006; Berger, Gerstenfeld, & Zeng, 2004). With regard to the discussion of a dominant retailer in a supply chain with multiple suppliers, studies often focus on its impacts on the profit, without considering the information flows in the supply chain (Geylani, Dukes, & Srinivasan, 2007; Wang, Lau, & Lau, 2009). Therefore, though information sharing can usually increase the performance and the profit of the supply chain as a whole, different types of supply chains may require different types of information sharing mechanisms, with different assumptions and conditions.

In a multi-echelon supply chain, the impacts of point of sale (POS) data sharing on the ordering decisions are contemplated, and the correlation between order decisions and information of demand is analyzed (Croson & Donohue, 2003). Also, by means of a simulation scenario, it is found that the sharing of POS would be useful to reduce the bullwhip effect for members in the supply chain, particularly for the sway of upstream members' orders (Croson & Donohue, 2003). Additionally, in the multi-echelon supply chain, the implementation of information sharing for downstream is more effective than that for upstream, because the reduction in the sway degree of order under downstream information sharing is less than that under upstream information sharing (Croson & Donohue, 2005). By investigating information lags and stochastic demand, the sharing of inventory information is found to be useful to diminish the bullwhip effect, and upstream supply chain members would be more beneficial than downstream members (Croson & Donohue, 2006). However, they fail to fully consider the impacts of promotion activities undertaken by the retailer on the market demand. Accordingly, the aim of this study is thus to examine information sharing in a supply chain with multiple suppliers and one dominant retailer, in which the information exchange can be used to reduce the risk of shortages and uncertain supply, and the profits can be optimized for both the whole supply chain and its individual members. Also, we consider information sharing between multiple suppliers and one dominant retailer, and particularly information sharing about the latter's demand and inventory. It is well known that Walmart shares weekly sales information with its suppliers and can thus manage to coordinate with the suppliers and mitigate the bullwhip effect along the supply chain. In fact, by analyzing the sales and inventory data regarding products, Walmart is able to share such information with the suppliers. That is, Walmart may estimate the product demand as well as the variations in inventory and shortage, and then pass the related information to the corresponding suppliers. This leads to a win–win situation for the supply chain members. Other dominant retailers, e.g., Carrefour, Costco, or Metro Group, may take account of the proposed method of this study and can thus sell a variety of products with low prices to maintain its competitive advantage in the long run.

This study focuses on the impacts of information sharing by the retailer on the cost and the inventory of the suppliers, and therefore the impacts on the retailer before and after information sharing are irrelevant. It is assumed that the information shared from the retailer to the suppliers is completely correct, i.e., the information obtained by the suppliers is identical to that of the retailer. Suppliers may forecast the retailer's order quantities according to the historical information. However, some factors may confuse suppliers in forecasting the order quantities for every period, such as the marketing activities undertaken by the retailer. This study differs from the related research in considering information sharing from a dominant retailer to multiple suppliers, and investigating the impacts of the promotion activities undertaken by the retailer at every period on demand for the next period. This paper is organized as follows: Section 2 states the research problem of information sharing in supply chain coordination, while Section 3 investigates the benefits of information sharing. Section 4 demonstrates the effectiveness of information sharing with a numerical example, and sensitivity analyses are also carried out to uncover the important factors which may influence the results. Finally, Section 5 presents the concluding remarks of this work.

## 2. The supply chain with one dominant retailer and multiple suppliers

Suppose that a two-echelon supply chain is formed by a single retailer doing business with $n$ suppliers, in which the suppliers provide different products with similar functions to the retailer, and then the retailer sells these varied products to customers. In other words, the products may be substitutable, and customers have different preferences about these products. It is assumed that, once a customer recognizes the various choices and decides to purchase one of the similar products, she would then have the probability $\alpha_j$ of choosing her original favorite product from supplier $j$. That is, she may change her mind to choose a similar product from other suppliers with probability $(1-\alpha_j)$. It is further assumed that each of the other $(n-1)$ products has the same probability of being chosen.

Suppose that the retailer, who faces the market directly, is able to collect historical sales data to realize the time series behavior of market demand, and then model it by an autoregressive process AR (1) (Chen & Lee, 2009), i.e., the demand for successive periods is correlated. Moreover, the retailer may undertake some promotion activities at every period, such as discounts, markdowns, and advertisements, to stimulate the demand of the next period. Upon obtaining the forecast demand, the retailer would determine the allocation of order quantities to the suppliers. However, the suppliers have to determine their inventory levels before receiving the orders from the retailer to fulfill the upcoming order quantities. It is assumed in this study that both parties adopt the order-up-