



# Information sharing in a supply chain with a make-to-stock manufacturer<sup>☆</sup>

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## ABSTRACT

We study ex ante information sharing in a supply chain consisting of a downstream retailer and a make-to-stock upstream manufacturer. The retailer has imperfect demand information and may choose to share it with the manufacturer. Based on the information sharing arrangement, the manufacturer makes the wholesale price and the stocking level decisions. Then the retailer decides the order quantity and the manufacturer fulfills the order up to the available stock level. We find that the retailer has an incentive to voluntarily share the information with the make-to-stock manufacturer if the magnitude of demand uncertainty is intermediate. This stands in sharp contrast with the existing studies which show that the retailer never shares information when the manufacturer is make-to-order. Our results highlight the interdependence between the retailer's incentive to share information and the manufacturer's operational and marketing decisions.

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## 1. Introduction

Modern data collection technologies have led to an explosion in both the scope and volume of customer and market data that are accessible to retailers. In the big data age, information sharing has been drawing heightened attention from practitioners and researchers. In 1990s, Electronic Data Interchange (EDI) was established between Walmart and its suppliers such as Procter & Gamble (P&G) and Johnson and Johnson, to share point-of-sales data. In 2000s, some initiatives such as Collaborative Planning Forecasting and Replenishment (CPFR) and Radio Frequency Identification (RFID) were adopted by Walmart and its suppliers, and this effectively facilitated sharing more accurate information between them. Information sharing through instruments such as EDI reduces the bullwhip effect along the supply chain (e.g. [30,31]) and brings significant value to supply chain partners (e.g. [6,14]).

However, incentives for information sharing are still an issue. Consider a supply chain consisting of a downstream retailer and an upstream manufacturer. It is known in the literature that if the manufacturer makes the wholesale price decision and the retailer makes the order quantity decision, the retailer does not have an incentive to share his private demand information with the

manufacturer (e.g. [33,49]). On the other hand, information sharing is widely observed in practice, usually initiated by retailers. Why? According to IHL research, the out-of-stock problem in North America costs approximately \$93 billion annually [27]. This is particularly a problem at the retail end where out-of-stock stubbornly remains at 8%, rising to over 15% during promotional periods [41,15]. Demand Clarity [15], a retail supply chain management consultancy, points out that the key reason for this retail out-of-stock phenomenon is that the retailer, where the information flow starts and the product flow ends, is disconnected with the supplier's production planning. Information sharing can help bridge the downstream retailing and the upstream production to reduce the occurrence of stocking out. Therefore, the retailer's incentive to share information is influenced not only by the manufacturer's wholesale price decision but also by its production or stocking level decision which directly impacts the likelihood of stocking out.

This paper attempts to rethink the retailer's incentive to share demand information in a supply chain by considering the manufacturer's multiple decisions, in contrast to some existing studies where the manufacturer only makes one decision such as price or capacity (e.g. [8,33,19,36]). We focus on ex ante information sharing commitment, where a retailer decides whether to share information before he observes the content of information. If firms agree to share information, they need to set up IT systems for information transmission beforehand (e.g. EDI). Many existing studies in this stream of inquiry investigate a retailer's incentive to share information with a make-to-order manufacturer. That is,

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the manufacturer produces and delivers the exact amount according to the order from the retailer. However, in some industries that require less customization, like daily necessities (e.g., P&G) and sports dress (e.g., Nike), the manufacturers are make-to-stock in that a certain stock level is built before their retailers place orders. When the manufacturer makes to stock, the incentive for the retailer to share information becomes more complex.

Our research questions include: How do the manufacturer's marketing decision (wholesale price) and operational decision (stock level) together interact with the retailer's information sharing strategy? When does the retailer have an incentive to share information and how does his benefit from information sharing depend on his information precision? How does the manufacturer's production mode (i.e., make-to-stock or make-to-order) impact the retailer's information sharing strategy? Under what conditions does the supply chain as a whole profit from information sharing?

We study these questions in the setting of a two-tier supply chain where the retailer is supplied by a make-to-stock manufacturer. The demand is uncertain and price sensitive. The retailer observes an imperfect signal about the demand. A three stage game is played. First, the retailer decides whether to commit to sharing the demand information with the manufacturer. After that, the retailer observes a demand signal which is revealed to the manufacturer if the retailer has committed to sharing information. Second, the manufacturer chooses her stock level and wholesale price. Finally, the retailer decides the order quantity and the manufacturer delivers the goods subject to the stock level. This model differs from the classical models in the literature on *ex ante* information sharing in that the information sharing arrangement interacts with both the manufacturer's marketing and operational decisions. On one hand, the retailer may like to conceal information to induce a low wholesale price when the market demand is high. On the other hand, he may like to share information to induce the manufacturer to build a higher stock level which would better serve the high market demand.

We have several interesting findings. We highlight the distinction between a supply chain with a make-to-stock manufacturer and that with a make-to-order manufacturer in terms of information sharing strategies and firms' profitability. The retailer never shares information with a make-to-order manufacturer but may do so with a make-to-stock manufacturer. Information sharing never benefits the supply chain when the manufacturer is make-to-order but may benefit the supply chain when the manufacturer is make-to-stock.

While sharing information has a direct negative impact on the retailer—the informational advantage disappears, it has a positive impact by inducing the manufacturer to build up enough stock for the high demand market. Information sharing has three impacts on the supply chain performance. First, it enables the manufacturer to confidently build enough stock for the high demand market. Second, when the demand is low, it induces a low wholesale price to guarantee a certain level of retail sales. Third, it renders a high wholesale price when the demand is high and reduces the sales. Although the first two impacts benefit the supply chain, the third works to its detriment. When the high demand is not attractive, the first effect is negligible. When the high demand is attractive, the third effect dominates the first two effects. We find that the retailer in balance has an incentive to share information when the magnitude of demand uncertainty is intermediate. Without information sharing, the manufacturer may build up just enough stock for the low demand market.

This paper belongs to the literature on the incentives for precommitment information sharing in supply chains. Li [33] and Zhang [49] show that when an upstream manufacturer serves multiple retailers who have private demand information, no

information sharing is the unique equilibrium outcome if the retailers make the order quantity decisions. Li and Zhang [34] show that when the downstream competition is intense, confidentiality triggers the retailers' incentives to share the demand information with the manufacturer, and that a wholesale price contract plus confidentiality can coordinate the supply chain. Ha and Tong [25] incorporate chain-to-chain competition into information sharing, and study how the downstream competition and contract types impact the incentives for information sharing. Gal-Or et al. [19] study the information sharing arrangement in a distribution channel when retailers are asymmetrically informed. They suggest that the manufacturer may choose to share information with only the less-informed retailer rather than with both. Yao et al. [46] consider a supply chain consisting of one supplier and two value-adding heterogeneous retailers. They study a retailer's incentive to share his cost information about the value-added service with the supplier. Shin and Tunca [40] examine the effect of downstream competition on incentives for demand forecast investments in supply chains. They identify contract schemes to coordinate the supply chain. Kurtuluş et al. [29] study the collaborative demand forecasting combination when both firms in a supply chain can invest to improve the quality of their demand information. Ha et al. [26] study how the incentive for vertical information sharing is impacted by the competition between supply chains, by the production diseconomies, and by the accuracy of demand information. Shang et al. [39] investigate the demand information sharing in a supply chain with two competing manufacturers selling substitutable products through a common retailer. In all these papers, the manufacturers make only marketing decisions, either wholesale price or other contract forms. In contrast, we study the incentives for information sharing, when the upstream manufacturer may adjust both the marketing and the operational decisions (i.e., the wholesale price and the stock level) according to information sharing arrangement. Therefore, our research contributes to the literature in two aspects. First, we show that the countervailing effects of the wholesale price and the stock level on the retailer's profitability may motivate voluntary information sharing that is commonly observed in practice. Second, we show that a manufacturer's mode of production (make-to-stock vs. make-to-order) has a salient effect on a retailer's information sharing strategy.

The value of vertical information sharing in supply chains has been substantially studied. In this line of research, manufacturers usually make inventory or capacity or stock level decisions. Representative papers include Bourland et al. [5], Chen [10], Gavirneni et al. [21], Lee et al. [31], Cachon and Fisher [7], Aviv [1–3], Fiala [17], Zhang [48], and Trapero et al. [42]. Chen [11] provides a survey of earlier work. The focus of these studies is the benefits of information sharing on firms' operational improvements such as ordering function, inventory allocation, and inventory cost saving. In contrast to these papers, we focus on the retailer's incentives for sharing private demand information when the manufacturer makes both the wholesale price and the stock level decisions.

Our paper is related to strategic or *ex post* information disclosure in a vertical channel where a downstream retailer makes the information sharing decision *after* the demand is realized. Guo [22] examines the impacts of the downstream firm's information acquisition and strategic disclosure to the upstream firm. Guo et al. [24] extends Guo [22] by investigating the strategic information sharing in two competing channels. In their models, the upstream manufacturers only make the wholesale price decisions. Chu and Lee [12] study the retailer's strategic disclosure of the demand information when it is costly to share information with the manufacturer who only makes the stock level decision. The aforementioned papers assume truthful information

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