A collaborative decentralized distribution system with demand forecast updates

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In today's global world, supplying several markets at dispersed locations with production from another market is a common business practice in many industries. In these distribution systems, the retailers have to place their orders before the actual market demand is known because of long production and transportation lead times. For example, fashion, telecommunication, and automobile industries are known to be subject to such long lead times. Moreover, the manufacturer's preferences for moving their manufacturing facilities to low labor cost countries further contribute to the total lead time that the retailers experience. Hence, they need to place their orders earlier, and consequently they face higher uncertainty of the demand that will be satisfied by those orders.

One way of dealing with high demand uncertainty is the pooling of inventory. Inventory pooling is known to reduce the risk of mismatching demand and supply, and thus it increases profit. Traditionally, the retailers physically consolidate their inventories to benefit from risk pooling. However, it may not be possible to implement physical pooling in global distribution systems because of the dispersed locations of the retailers and customers' unwillingness to wait until the products are delivered from a central warehouse. In such situations, the retailers have to keep stock at their local facilities in order to satisfy their customers. However, there are alternative ways to benefit from risk pooling. It is well observed in many industries that forecast accuracy is increasing dramatically as the selling season approaches. For example, in fashion industry, reducing the lead time from eight months to four months was estimated to reduce forecast errors from 65% to 35% (Iyer and Bergen 1997). High forecast errors are also common in other industries (e.g., telecommunication and electronic industry) as the customers usually place huge orders at once and it is hard to predict when the actual orders will be materialized. Any opportunity of reallocating initial orders through the use of updated forecasts helps the retailers to match the demand and supply, and increase profit. These opportunities can arise in several scenarios, such as:

1. Consider a group of distributors (e.g., catalog merchandisers and outlet stores—see Eppen and Iyer 1997) buying fashion goods to sell in their separate markets. Once their orders are ready, the distributors can redistribute these orders according to their updated forecasts.

2. Consider a group of business units of a telecommunication company that serve separate regions within Europe. It is a recent business practice in telecom industry that, once the products are fully or partially produced, they are distributed through an integration center, where the final products are assembled and/or configured according to the customer specification. Once the products come to the final assembly and configuration stage, the distributors can decide on the actual quantities by using their updated forecasts.

For simplicity, we hereafter refer to any location (e.g., port, warehouse, cross-docking station, integration center etc.) in which reallocation of the previous orders can take place as a warehouse.

In decentralized distribution systems described above, it is crucial to find a stable way of allocating the extra benefits from joint activities (i.e., inventory pooling in our case). Without that, it would not be possible to establish the participation of all potential retailers, which is desirable from the system point of view. Even within a global organization (which promotes global planning activities) such mechanisms plays an important role in bringing together regional units (which usually act as independent entities and are evaluated according to their individual performance) and inducing them to collaborate in these activities.

In this paper, we consider a distribution system that consists of a manufacturer, a warehouse, and n retailers. Each retailer sells an identical product, made by the manufacturer. Due to long production and transportation lead times, they have to place their orders without knowing the exact value of the demand, but they have information about its distribution. The orders arrive at a warehouse after some production and transportation lead time elapses, during which time the retailers update their demand forecasts. We first focus on cooperation among the retailers where the retailers jointly place their orders and can reallocate the amount that they ordered by taking into consideration the updated forecasts. We investigate a cooperative game between the retailers that abstracts away the details of mechanisms leading to cooperation but allows us to analyze the problem of profit division in more detail. We prove that there exists a stable allocation of joint profit among the retailers by showing nonemptiness of the core of the associated cooperative game. In addition, we show how a core allocation may be computed. Hence, when such an allocation is used, cooperating retailers prefer the grand coalition to being in any other alliance. Although intuition suggests that allocations that considers updated demand forecasts always improve the system profit (and cooperating retailers hope to achieve higher total expected profit), the detailed model of demand updating process allows us to identify the cases in which the reverse is true; that is, the actual performance of the total supply chain might be worse. With help of an example we illustrate that asymmetric forecasting capabilities and accuracies of the retailers might harm the cooperation if the retailers receive relevant data about each others demands, and forecast sharing might lead to bad performance. Moreover, this also leads to the nonintuitive conclusion that better forecasting abilities do not always improve the system performance in this cooperative setting. To overcome this discrepancy, the retailers can further collaborate by sharing their demand signals and performing joint forecasting activities. We extend the analysis by considering cooperation among the retailers with joint forecasting, and show that the core is nonempty in this case as well.

Following this, we concentrate on the relationship between the manufacturer and the retailers. We consider a general three-parameter contract, called the *extended buyback contract*, between the manufacturer and retailers. Under this contract, the manufacturer charges a wholesale price for the initial orders. After the products become available in the warehouse, the manufacturer accepts any returns at a lower buyback price. Moreover, the manufacturer pays a compensation price for any unsold products at the end of the selling period. Unlike a traditional buyback contract, extended buyback contract allows the manufacturer to offer a buyback opportunity to the retailers after the demand update (when the orders arrive at the warehouse), but before the demands are realized at the retailers' markets. This opportunity is especially important if the manufacturer can salvage items left at the warehouse. For a manufacturer who serves several markets, it might be possible to direct some inventory left over in one market to a secondary market directly or after some reconfiguration and refurbishment of the products. We incorporate this possibility into our model by defining a positive salvage value at the warehouse, which can only be realized by the manufacturer. Our analysis suggests that the retailers' cooperation may have a positive or a negative impact on the manufacturer's profit.

It is known in the literature that centralization increases the profits in distribution systems and that buyback contracts are capable of coordinating the system with a single manufacturer and a single retailer. In addition, any allocation of joint profit can be achieved by an appropriate buyback contract. These results can be extended to our model with multiple retailers if the retailers are symmetric with respect to their margins (i.e., if the difference between the selling price and the transportation cost is the same for each retailer), or if the demand signal reveals perfect demand information. Moreover, the manufacturer prefers retailers' cooperation since he/she gets a share from improved performance under such a contract. On the other hand, if the demand signal is not perfect and the retailers do not have symmetric margins, the buyback contract fails to reach the profit level of the centralized system (even if it induces optimal order quantities and optimal returns at the warehouse) whenever the wholesale price exceeds the production cost of the manufacturer.

References

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