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Optimal responses to stockouts: Lateral transshipment versus emergency order policies

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ABSTRACT

In the retail industry, stockouts have a significant effect on a firm's profitability. When a stockout takes place, retailers often apply one of two strategies to resolve the issue – placing an emergency order with their supplier or arranging a lateral transshipment with a nearby partner store. Choosing the optimal response to a stockout is complicated by customers' spontaneous reactions. Customers who find that a product is out of stock may choose to give up on the purchase, to wait for delivery (through emergency order or lateral transshipment), or go to a partner store to search for the product on their own. In this study, under a single-period setting with two retail stores, we investigate the optimal inventory decisions under each strategy, and conduct a comparison between lateral transshipment and emergency order options. We also analyze the effects of the customer requesting rate and switching rate on the optimal inventory decision. Through numerical analysis, the two strategies are compared in terms of inventory levels and profitability. The results suggest that in addition to the cost associated with each of these strategies, the customers' behavior in response to a stockout has a significant effect on the optimal decision. The emergency order strategy is a better option when more customers request deliveries or when more customers switch to another store. Extending this analysis, we also examine the combined strategy when an emergency order is placed after a transshipment fails to fulfill unmet demands, and explore the circumstances under which this strategy provides the highest additional profit for the stores. Finally, we also find that a higher requesting rate does not necessarily increase profits, particularly when there is a high customer switching rate, because requesting emergency order or transshipment reduces switching demand.

1. Introduction

Running out of stock is a common problem in the retail industry. According to a report from SCDigest [26], "more than 1 in every 5 consumers (21.2%) coming into the door of Consumer Electronics retailers leave without buying at least one product they intended to purchase due to out-of-stocks." This report also pointed out that one of the biggest revenue losers, out of the retail outlets examined, was Office Max that had an out-of-stock rate of 30.6% and was losing $1.96 for every customer coming through its doors due to lack of stock.

If a stockout occurs, retailers can place an emergency order with their supplier (EO policy), or arrange lateral transshipment from partner stores (LT policy) to solve the problem. Placing an emergency order to meet customers' extra demands is often easily done; it is quite common that overseas employees work overtime to fulfill additional orders placed in this fashion. However, lateral transshipments can also be a practical business solution. For example, if a car dealership does not have the car a customer desires in stock, it is often simple to arrange a shipment of that item from a partner dealership.

Both emergency orders and lateral transshipments can be used in stockout situations. In general, emergency orders tend to take longer and be more expensive. Lateral transshipments are faster and cheaper, but are restricted by the availability of inventory at partner stores. Given these restrictions, it is unclear under what circumstances a retailer should pursue one strategy rather than the other, and it is worthwhile to investigate these two policies under a comparative framework.

However, it is also important to take into account how customers react to stock shortages. Some customers may be willing to wait for a delivery, whereas others may choose to go to a different store and look for the product on their own. There may also be some customers who simply give up on purchasing the product. In this study, we assume that customers who cannot acquire their desired product will

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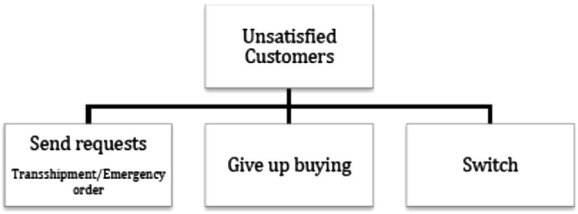
take one of these three actions – requesting, switching, or not buying. "Requesting customers" are those who submit a request to the retailer to be satisfied by either an emergency order or a transshipment. "Switching customers" are those who switch to another store to search for the product on their own.



In this study, we are interested in addressing the following research questions: (1) When a stockout occurs, what is the optimal order quantity for both emergency orders and transshipments? (2) What are the optimal inventory decisions for retailers before demand realization? (3) Which stockout response strategy should a retailer adopt in different situations? (4) How are optimal initial inventory and stockout response decisions affected by costs and customer behavior?

To address these questions, we construct a one-period model with two retail stores facing random demand under a centralized system. If the firm decides to adopt an emergency order policy, then it will make optimal inventory stocking decisions before selling to customers. After demand realization, if there are any unmet demands at a store, customers take one of three actions – requesting, switching or leaving. The firm then places emergency orders for the requesting customers. The other store will satisfy switching customers, if it has excess inventory available. However, if the firm adopts a lateral transshipment policy, it also makes an initial inventory decision, but after demand realization, it allocates some of its excess inventory at one store for switching customers and transships the rest to satisfy requesting customers.

Our results suggest that stores will always gain more profits, regardless of the strategy used, when there are higher rates of customer switching. However, the same is not necessarily true when there is a higher requesting rate. Through numerical study, we compare the total profits under the two strategies. Intuitively, a lateral transshipment policy utilizes unused inventory at one store to satisfy unmet demand at another store and therefore efficiently reallocates resources. However, this strategy is limited by the amount of unused inventory at the second store. Emergency order policies do not have such a constraint but are often more expensive and take a longer time. We find that a lateral transshipment strategy is more appropriate when fewer customers request a transshipment or emergency order, and when fewer customers switch to the other store.

Although we initially study emergency order policy and lateral transshipment policy separately, it is possible to implement both strategies together. We also consider a hybrid strategy in which a transshipment is arranged first and then, if there is still unmet demand, an emergency order is placed. Therefore, one other question that we address in this study is when this combined strategy will yield the most extra benefit. Interestingly, using a hybrid strategy may not result in more profits in every situation. We conduct numerical studies to investigate when each strategy dominates and the magnitude of the relative benefits, thus taking into account whether the additional administrative effort and cost of a hybrid strategy is justified given individual circumstances.

2. Related literature

A tremendous amount of research has been devoted to both emergency orders and lateral transshipments as part of the search for effective solutions to increase multi-echelon supply chain performance.

In the literature, a number of inventory models assume that there is an option to place new emergency orders if a shortage happens. Emergency ordering procedure is triggered once on-hand inventory reaches a certain level. Using a periodic review inventory system, Chiang and Gutierrez [3] outline the optimal control policies at each review time point. Jain et al. [10], Lawson and Porteus [14], and Gaukler et al. [5] have all conducted similar studies. Sawik [25] considers the case that the emergency inventory can be pre-allocated to the suppliers who are selected to be protected at the beginning. Recently, Pando et al. [21] extend the newsboy model and allow a fraction of unmet orders to be placed. The optimal order quantity can be obtained in a closed-form expression when customer demand follows an exponential distribution. Other emergency order studies include those by Nickel et al. [17], Liu and Papageorgiou [16] and Yang et al. [32].

Transshipment problems have been analyzed from many different perspectives. For example, Tang and Yan [30] create a model in which transshipments can be applied during both pre-distribution and post-distribution cross-docking operations. However, in this study we only review directly related research work, namely those that consider transshipments conducted after customer demand is realized. Krishman and Rao [13] may have been the first to explore a single-period two-location problem and its N-location extension. Robinson [22] considers a multi-period, multi-location problem in which products are relocated among different sites. Assuming zero transshipment and replenishment lead times, Robinson [22] then derives the optimal ordering policy and finds analytical solutions for the two-location case. Hu et al. [8] study multiple period settings but focus on two-location transshipments. Zhao et al. [33] study dynamic transshipment policies for a multi-location problem. Olsson [18] claims that a unidirectional lateral transshipment policy is reasonable, if the locations have very different backorder costs or lost sales costs. More recently, Heide and Roodbergen [6] study the transshipments of books with online demand, aiming to minimize the cost of logistics within a library system. Using stochastic dynamic programming, Heide et al. not only provide the optimal policy for small instances, but also two heuristic approaches for larger scenarios. Rosales et al. [23] compare the transshipment approach with the allocation method that allows products to be transported to retailers from a centralized depot without cost. Stochastic programming models are also used to explore the performances of both methods under a wide range of different scenarios. An overview of the literature indicates that transshipment dominates other allocation methods in most cases. For instance, Sven Axsäter et al. [2] consider an N-retailer inventory system; when stockouts occur, transshipments are transported from the outside support warehouse. The model they propose can significantly reduce the expected holding and transshipment costs while maintaining the same fill rate.

Most early studies assume that there is a centralized inventory planner that coordinates optimal inventories and transshipment decisions. There are also models that include individual decision makers. For example, Rudi et al. [24] initially consider a two-retailer, decentralized, one-period system and prove the uniqueness of the Nash equilibrium in order quantities. Hu et al. [7] discuss the existence of coordinating transshipment prices. Huang and Sosic [9] study a repeated inventory sharing game with N retailers and the profit of transshipments distributed among retailers by dual allocation. Furthermore, Krishnan et al. [12] propose incentive mechanisms for independent retailers to participate in transshipments. Other related studies include those by Tagaras [28], Tiacci and Saetta [29], Wijk et al. [31], Pan and Nagi [20], Özdemir et al. [19], and Gong et al. [4]. However, as a first step to tackling the research questions outlined above, we will