Online Order Fulfillment with Central and Local Warehouses

Our project is motivated by a consulting project with an e-tailing company which sells product purely online. The e-tailer faces the problem of where to and how to allocate the inventory. The company provides quick delivery service to customers. If it keeps the inventory in suburban area (and thus far away from the customers), then it can enjoy a low warehouse renting cost but the shipping cost would be high if it wants to deliver the product to the customers in a timely manner. If it puts the inventory close to the customers, then it can save the shipping cost but the warehouse renting cost would be high. Another option is to keep inventory in both local and remote places.

In order to answer the question, we model a monopolistic firm that sells product to customers via internet. The firm needs to decide where to locate the inventory and it has three options: keep all the inventory in central warehouse in which the inventory holding cost is low but the (expedited) shipping cost is high, keep all the inventory in local warehouse in which the inventory holding cost is high but the shipping cost is low, or keep inventory in both warehouses. In any option, the firm also needs to decide how much inventory to keep in either warehouse. The demand is uncertain and it is realized after the firm decides where to locate and how much inventory to locate. The firm uses the inventory in central (resp., local) warehouse to fulfill the demand if it keeps all the inventory in central (resp., local) location. When inventory is stored in both central and local warehouses, the firm first uses the local inventory to fulfill demand. If the number of customers who want to buy the product is more than the amount of local inventory, then the firm can use the inventory in central warehouse to fulfill the unmet demand by incurring an expedited shipping cost. Any demand more than the total inventory kept in both locations would be lost. There may be leftover inventory in either or both warehouses. For the inventory left in central warehouse, the firm can salvage it to third-party clearance companies. If there is inventory left in local warehouse, then the firm needs to salvage it in local market (i.e., mark down and sell it in local market) since it is inconvenient or costly to have the clearance companies to transport to local market/place to collect the leftover; third-party clearance companies could do it with central location because of the warehouse facility and transportation convenience there. Customers in local market can get access to the local leftover if any.

We study three types of customers: myopic, strategic and bargain hunters. Myopic and strategic customers are high-end customers in that they have high valuation for the product and they can afford the product with full price, while bargain hunters can afford the product only when it is marked down. Strategic customers are forward-looking. They know that the leftover (if any and if stored in local warehouse) may be marked down and on sale in the market. So strategic customers may delay their
purchase to wait for the leftover if they expect that the utility surplus from buying the leftover is higher than the utility surplus from buying the product in full price. In contrast, myopic customers do not consider or do not realize the waiting option, and they buy the product in full price as long as their utility surplus from buying is non-negative. We assume that both myopic and strategic customers have homogenous valuation.

We find that when the high-end customers are myopic, the firm should always keep some (if not all) inventory in local warehouse, and thus keeping the inventory in central warehouse only can never be the optimal option when customers are myopic. This is consistent with practice that now a lot of e-commerce companies build up small warehouses in local community close to customers, even if the holding cost there is higher than the holding cost in central warehouse which is usually located in remote area far away from the city. Second, when the (expedited) shipping cost is low, the firm should keep inventory in both locations. Otherwise, the firm should keep all the inventory in local warehouse.

When high-end customers are strategic, we find that the option of keeping all the inventory in central warehouse can become optimal, while this cannot occur when customers are myopic. This is because strategic customers are forward-looking and have a tendency to wait if they can get the marked-down leftover. When keeping all the inventory in central warehouse, strategic customers cannot get access to the leftover and thus their waiting incentive is zero, while their waiting incentive is positive if there is any inventory stored locally. Therefore, with strategic customers, comparing to keeping inventory in both locations, storing all the inventory in central warehouse not only saves holding cost, but also eliminates customers’ waiting tendency, and the second advantage does not exist when customers are myopic. This is why the option of keeping all the inventory centrally becomes more attractive and can dominate the option with both locations when customers are strategic. We also find that the firm’s profit can increase in the local holding cost when there is some inventory stored in local warehouse. This is because a higher local holding cost leads to a lower inventory level in local warehouse and then a lower waiting incentive. With a lower waiting incentive, the firm can charge a higher price to induce strategic customers to purchase early, which favors the firm’s profit. This behavior effect can dominate the direct economic impact of a higher local holding cost which hurts the firm’s profit, especially when customers are highly strategic.

Our analysis also shows that when customers are strategic, if the firm can creditably commit to throw away all the leftover in local place, then it always earns a higher profit by keeping some or all the inventory in local warehouse compared to using central warehouse only. Traditional e-commerce companies usually rely only central warehouse to fulfill the order. Our result suggests that these companies can always become more profitable by adding a local warehouse as well as committing to
throw away leftovers. We also find that the firm with both warehouses should commit to throw away the leftover only when customers are highly strategic. Otherwise, the benefit from reducing their waiting incentive may not be enough to compensate the revenue loss of the leftover. Committing to no markdown price for the local leftover has the same impact on the firm’s profit as that of committing to throwing away the local leftover, and the firm should use this commitment when customers are highly strategic. Since it is easier for customers to verify "no markdown price" compared to the firm indeed throwing away local leftover, it may be more applicable for the firm to commit to the constant price.