Value and Cost of Adopting Upfront Warehouses for Apparel Retailing Networks

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Retailing industry has undergone significant reforms in recent years due to the development of e-commence. Customers gain more convenience in deciding what, when and where to shop. Facing the new challenge, traditional brick-and-mortar retailers are re-constructing their supply chains to enhance their quick response capabilities that would capture more sales opportunities.

The traditional supply chain of brick-and-mortar retailers are mainly designed for cost-efficiency, but not for quick response. Generally, a regional warehouse, which is located outside urban areas, regularly fulfills stores' replenishment orders in batches. The average fulfillment frequency of the studied firm is about once a week. With more fluctuated demand and increased number of stock keep units (SKUs), as the result of e-commerce, slow fulfillment response inevitably leads to more stockout. Companies opt to make many transshipments between stores to alleviate stockout. Because the transshipment incurs a large cost, which is almost comparable to the logistics cost from the regional warehouse to stores, the current practice is inevitably unsustainable.

Upfront warehouse is adopted by many companies to improve their supply chains response speed. Upfront warehouses are small-to-medium sized warehouses located in the city. Different from large regional warehouses that replenish orders in bulk sizes, upfront warehouses are designed to fulfill small orders in a quick mode. Typically a limited number of popular SKUs are stored in the upfront warehouses due to the limited space. Upfront warehouse is thus a complementary layer between retail stores and the regional warehouse to provide "quick response" to demand. In China, many grocery stores have used upfront warehouses to deliver both online and offline orders in hours. In the U.S., Walmart adopted a similar strategy called "dark store" to quickly fulfill their online orders.

Despite the industry-wide exploration in adopting upfront warehouse, we find little literature in this topic. In this study, we use the transactions, inventory, and delivery data from an apparel retailing company in China to empirically study the benefit and cost of adopting an up-front warehouse. Specifically, we want to investigate the following research questions. (1) Sales. Whether the implementation of the upfront warehouse causes an increase in sales? (2) Inventory levels. Thanks to the quick response, store managers do not need to worry about the potential stockout and may reduce their inventory levels. So whether there is a decrease in inventory levels? (3) Transshipment. To some extent, the upfront warehouse

can balance product distribution among all stores. As a results, the transshipment between stores would decrease.

The company we studied is a leading retailing company selling child athletic apparels of a top brand. It has 43 stores in Shanghai China, sells about two thousand skus per season, including shoes, apparels, accessaries, etc. The supply chain structure used to be a conventional two-echelon structure. All stores were provided by one regional warehouse (RW) in Kunshan, a city several hundread kilometers away from Shanghai. The average lead time was more than 24 hours. In March 2018, the "In-City Upfront Warehouse" plan was officially launched. The company rents a small upfront warehouse (UW) in Shanghai city to reserve certain products. When a shortage or a low-inventory status occurs in physical stores, products from the UW can be delivered within 4 hours. This radically changed the supply chain structure, from two-echelon to three-echelon structure. That is RW-UW-Store structure. The supply chain works as followings. First, the RW still regularly delivers necessary goods to physical stores to ensure regular business. Second, the RW also provides products for the UW to keep its inventory at a reasonable level. Third, as a complementary way to the regular delivery, the UW can quickly respond to shortages in physical stores.

The data we get includes transaction records, monthly beginning inventory level records, transshipment records, and basic information about stores. The time ranges from Jan 2017 to Jan 2019. More specifically, the transaction data includes store ID, SKU ID, the time of the sale, the amount of sold products, and their prices at the time of the purchase. Inventory level records include the inventory level for each SKU in each store at the beginning of each month. Combining inventory level records with transaction records and transshipments records, we can calculate daily inventory levels for each SKU in each store. Transshipment data contains all transshipments, on a daily level, among the three-echelon supply chain structure, no matter it is a downstream, upstream, or parallel shipping. For each transshipment record, it includes SKU ID, the amount of each SKU, origin, destination, the time when the package departures, and the time when it is received. Stores' information includes locations, the distance from the UW, and other basic characteristics.

Nevertheless, the analysis is quite challenging. To accurately measure the value of the UW, we have to handle numerous confounding factors and selection bias. These challenges can be divided into two groups. (1) Commodity-related challenges. First, due to the limited capacity of the UW, the company only reserves some popular and best-selling SKUs in the UW. As a result of that, the observation data is influenced by selection bias. Second, for every season, new products will come into the market, and out-of-date products will be sold in a clearance sale. Thus products in the last season are entirely different from the products in the next season. And one commercial season only lasts for three months, so evaluating the value of the UW by comparing one product's performance before and after treatment is almost impossible. (2) Store-related challenges. First, to guarantee that replenishments can be finished within 4 hours, the company only selected a part of stores that are located in the UW's service area as receivers of the upfront warehouse, which also causes selection bias. Second, the strategic position of each store is variant, and the product variety and inventory levels are distinctly different among stores. Thus, even though two stores are both

served by the UW, benefits can be different. Heterogeneous responses may exist. Third, the mall where a brick-and-mortar store is located can also influence the commercial activity by supervision and promotions. All the above confounding factors would have an influence on the estimates and make the analysis challenging.

We adopt the difference-in-difference framework to identify the value of the UW. We regard stores supported by the UW as the treatment group while we regard other stores as the control group. Similarly, periods after the plan launched are regarded as the treatment group, while periods before the plan are regarded as the control group. The difference-in-difference framework rules out the selection bias effect with respect to stores, but the heterogeneous response may exist. One indicator describing whether one specific store is a star store or not is introduced to measure the potential heterogeneous response effect. For products, we adopted the propensity scoring matching (PSM) to match each SKU in the treated year with one SKU in the previous year. Features, including category, color, gender, age, price, the number of stores to which the first batch is delivered, are leveraged to calculate the propensity scores. In addition, an extra regression is conducted to demonstrate that the chronic trend assumption in the DID framework holds.