Ship-pack Optimization in a Two-echelon Distribution System with Product Obsolescence

In many common two-echelon distribution systems, a Distribution Center (DC) replenishes inventory for multiple downstream locations such as retail stores in ship-packs. For most products, i.e., Stock Keeping Units (SKUs), a DC receives the product in large case-packs or pallets (multiple case-packs), as opposed to individual units, from their suppliers. Subsequently the DC needs to decide whether to replenish stores using the original case-packs, or break these packages down to their “inner”-packs (i.e. cartons that contain multiple units of the product), or further break the inner packs into “eaches” (i.e. single units). The choice of ship-pack size not only affects the logistics operations in DCs (such as receiving, storing, put away, picking, transportation, etc.) but also, influences the retail stores’ operations.

There are several advantages to shipping products to stores in case-packs. First, DCs incur lower costs since they need not break down the packages into inner-packs and eaches; replenishing stores in inner-packs and eaches requires additional handling cost at the DC (opening the case package, repackaging the product for order fulfillment, etc.). Second, suppliers often design case packages to fit the automated conveyance at the DCs and hence require minimum handling by DC’s labor. Third, these packages are designed by suppliers to protect the products from potential damage during picking and transportation operations. Nevertheless, it is often sub-optimal for stores to receive inventory in case quantities. For example, a replenishment of a single case-pack of 24 units may be too much, and may result in excess inventory for low-demand, short-life-cycle products such as electronics, entertainment, and apparel. Therefore, many retailers prefer to replenish their stores using smaller ship-packs such as inner-packs or eaches. However, replenishing stores in inner-packs or eaches incurs additional handling costs and complicates the operations at both the DC and stores. For instance, a DC will often use totes to combine and ship the replenishment orders of several SKUs whose ship-packs are inner-packs or eaches. At the retail store, associates
then need to open up the totes, sort the products, and put them onto shelves, all of which takes labor time. If an order delivered to a store does not fit on the shelf space allocated to the product, the excess units must be stored elsewhere in a store, typically in the backroom; which results not only in extra handling costs, but also a higher likelihood of pilferage and damage.

The choice of packaging influences the inventory level at each store. Many retailers use inventory planning tools to determine for each store the reorder-up-to-level for each SKU, based on demand forecast, store specific information and presentation inventory requirements. However, these tools often fail to incorporate ship-pack size into their decision-making processes. This oversight can result in a store being replenished with a case of 24 units when much fewer units are needed; this can lead to more inventory than needed and subsequently higher inventory carrying cost for retailers. A higher inventory level will also increase the likelihood of markdown for obsolete products. Furthermore, when stores are replenished in cases, the DC sees larger demand variability and can be subject to the “bull-whip effect”; consequently, the DCs must carry more safety stock.

In this paper, we partner with a major US-based retailer (hereafter referred to as Gamma) to develop and test a cost model that captures the supply chain costs associated with ship-pack choices. At the time of the research, Gamma was concerned with the challenge of managing the inventory for SKUs with short product life cycles and high obsolescence costs, while striving to contain labor costs at both DCs and stores.

To handle obsolete inventories, Gamma typically initiates a clearance period over which it gradually reduces the sales price of a SKU with excess inventory. Any unsold items after the clearance period must be transported back to DCs to be sent back to the original suppliers, or in the worst case, to be disposed; in this case Gamma incurs an additional disposal cost. For these items, the retailer faces millions of dollars in profit loss and transportation costs.
Almost all classes of products will have to be discounted at some point in their selling cycle. For approximately 52% of SKU classes their markdown percentages are negative, implying that those SKUs are sold at clearance prices that are below their procurement costs. Sending more inventory than necessary from DCs to retail stores due to ship-pack choice may result in additional obsolete inventory costs, which could be extremely costly to retailers who carry products with short life cycles and significant negative clearance gross profit margins. Using a smaller ship-pack is one tactic to minimize the store inventory levels and mitigate the risk of dealing with obsolete inventory. Yet, replenishing more SKUs in eaches or inners has an impact on the DC operations at Gamma. Replenishing in eaches or inner packs requires additional handling if they are not suited for transportation using the automation system at DCs. Such ship-packs need to be handled by manual labor in a separate area in the DC called the “repackaging area,” where a number of inners and eaches of different SKUs are repacked in totes for shipping to stores. Another point of concern is that the repackaging shipments in the supply chain are growing both in volume and in size. In the past five years, Gamma has experienced a 45% increase in repackaging item volume in its DCs while the DC repackaging footprint has remained relatively constant.

In summary, Gamma faces a major trade-off in regard to selecting its ship-pack sizes. On one hand, its DCs prefer to ship case-packs to avoid additional labor, handling, and repackaging costs; on the other hand, the stores prefer to be replenished in inners and eaches to avoid having to deal with obsolete inventory costs. We show that optimizing the ship-pack size can reduce these costs by 9% for Gamma. We further use the cost model to explore the impact if Gamma were to renegotiate the ship-pack configurations (i.e., the unit quantities for each inner and case) with its vendors. Doing so, we find a total cost saving of 17% with respect to the original ship-pack sizes for a test sample of products.