E-Commerce Drop shipping: Building a CPG Supply Chain

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Abstract

Manufacturers and retailers are increasingly interested in exploring different ways to optimize their fulfillment of e-Commerce orders. An approach that is often considered is drop-shipping, where the manufacturer takes on the responsibility of shipping directly to the consumer. Retailers are interested in this model as it shifts their inventory responsibility upstream and frees up working capital. Manufacturers are intrigued by drop shipping as a means of capturing lost sales on high-value, seasonal products that retailers might be under-stocking. These manufacturers currently lack the retailer-side inventory availability information to assess the extent of this opportunity. We propose a framework to show manufacturers and retailers how to examine the key issues of drop shipping such as capacity constraints, per unit distribution cost, changes in working capital, cost allocations in the supply chain and delivery time to customers. We also explore how to bridge information gaps to gauge inventory availability and lost sales using Web Extraction System data. We demonstrate our framework by partnering with a CPG manufacturer interested in implementing drop-shipping. Using their data from an existing facility and a selected retailer, we simulate drop shipping orders for a specific set of products during the holiday season that are normally fulfilled by the retailer. Firstly we show that in this scenario, the manufacturer will not exceed their current facility's capacity and will require minimal changes to their existing operations. Using Activity-Based Costing (ABC), we then find that the overall channel costs are only slightly more expensive than those in the traditional model. However, the manufacturer takes on a much larger portion of those costs than they would in the existing model. The transfer of the distribution labor and inventory holding costs from the retailer to the manufacturer drives these cost shifts. As expected, we found significant working capital benefits for the retailer when shifting to drop-shipping. To understand the potential gains that could be achieved from capturing lost sales, we paired data from a Web Extraction System with Point-of-Sale data to obtain previously unavailable retailer inventory information. Contrary to initial expectations for this scenario, the retailer displays very high inventory availability, making lost sales a weak justification for adopting this model. Lastly, using publicly available time-in-transit tables, we model the changes in delivery time that customers experience. The results show that the average delivery time increases by one day for most locations in the US. Our framework and analyses contribute to developing an understanding of the opportunities and implications of drop shipping. In addition, we introduce new techniques manufacturers can use to deal with asymmetric inventory information.

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1. Introduction

This thesis assesses the viability of a large CPG manufacturer to distribute goods directly from its distribution centers to the customer on behalf of an online retailer (e-tailer), a practice which has been coined "drop shipping" or "direct-to-consumer". The work was initially motivated when a large retailer with both a physical (nationwide chain of stores) and online presence requested that one of their large manufacturers assume responsibility for order fulfillment (drop shipping) of high value products. We propose a framework that manufacturers can use when considering offering drop shipping to a retailer. The framework can help to guide their approach in evaluating the request.

In this thesis, we consider how integrating drop ship operations into a manufacturer's current distribution network would impact each facility's capacity. It is imperative that this new volume is considered in its own context- there are great differences between shipping pallets to warehouses and shipping consumer's individual packages. We also explore the incremental distribution costs a manufacturer incurs with the drop ship process. Fulfilling these individual orders will require additional labor cost and packaging materials. For example, the manufacturer will now be packing each order into cardboard boxes, a task which was previously paid for by the retailer. In addition, the manufacturer will now need to carry incremental inventory to fulfill consumer orders, which requires more working capital.

We build a model to better understand the overall supply chain costs and show how costs shift among the parties involved (retailer and manufacturer) under the drop shipping model. As these costs shift between parties and as the costs of the supply chain as a whole change, it is crucial that the manufacturer accurately accounts for its increased burden. It will need to consider modifying its agreement with the retailer to recover these costs or even charging a premium for the drop shipping service.

Complementing the cost discussion, we consider potential revenue benefits of drop shipping. In some instances, the manufacturer may choose to hold more inventory than the retailer did. This could reduce the number of stockouts and capture sales that may have been previously lost during periods of intense demand at retailers. We propose a method to enable manufacturers to quantify this lost sales opportunity using web extraction tools to gather previously unavailable retailer inventory information. Another benefit, which is not quantified, is the potential for a more direct relationship with the consumer. As part of this relationship, the manufacturer must consider how lead times that consumers experience might be impacted.

In order to protect the CPG partner's identity and competitive strategy we have masked any identifying information including SKU name, location data and retailer information.

We begin with a literature review of relevant e-Commerce and drop shipping publications.

2. Literature Review

This literature review will highlight some of the recent developments in e-Commerce practices and the advantages and disadvantages of drop shipping through both a retailer's and a manufacturer's lens. The research will also explore the drop shipping model's potential to benefit from additional sales that would be otherwise lost due to retailer stockouts and the potential service impact on consumers.

2.1 The development of e-Commerce

The internet and information technology have significantly shaped today's consumer purchasing behavior and propelled the rise of e-Commerce. In 2013 alone, 191.1 million people were classified as online shoppers[1] in the US, with an increase to around 215.1 million expected by 2018 (eMarketer, 2014). A survey of 39 retail executives developed by the consultancy Deloitte in 2011 projects that revenues from traditional sales channels would represent only around 63% by 2016, down from around 91% in 2011 (Gomez & Fritsch, 2012).

In the face of this change many large retailers such as Wal-Mart and Target have moved from the traditional brick-and-mortar stores to pursue omni-channel retailing models. In these omni-channel models, retailers retain their existing physical store networks and complement them with online channels.

2.2 The new e-Commerce distribution model

These new retailing models have necessitated a number of changes to retailers' supply chains, particularly in the area of order fulfillment. Typically, retailer distribution networks were designed and optimized to ship crates and pallets to physical retail stores. However, the orders coming through the e-Commerce channel require supply chains to accommodate picking of 'eaches' for the consumer (Jones, Lang and LaSalle, 2012). In addition, retailer networks were often not intended to cater to large numbers of geographically dispersed customers and lacked the distribution infrastructure to reach consumers within

[1] Defined as having browsed products, compared prices or having bought an item online at least once (Statista, 2015)

one to two days (Chaturvedi, Martich, Ruwadi, & Ulker, n.d.). This is further complicated by the consumer's expectation of having the ability to shop from a huge assortment of SKUs.

To address the large differences in supply chain requirements, many large retailers have adjusted their model by adding separate distribution networks to fulfill e-Commerce demand. Wal-Mart uses this technique today, servicing all of their e-Commerce orders through separate management and fulfillment facilities. In this new model, the product first travels from the manufacturer to a retailer's Distribution Center (DC). It is then forwarded to the retailer's e-Commerce DC network, from where it can be shipped directly to consumers via a parcel carrier. While this strategy allows retailers to address specific challenges that result from the unique profile of online orders, it also generates new issues we will discuss below.

2.3 Stockouts and the new distribution model

One of the key areas that can be impacted with this model is inventory stockouts. The separated e-Commerce distribution model can "lead to poor cross-channel coordination across channel-specific inventory pools and fulfillment processes, causing higher out-of-stocks and markdowns in any given channel, especially during peak seasons" (Chaturvedi et al., n.d.). Besides a lack of coordination, the above-mentioned stockouts in certain specific categories can also result from longer lead times. Now, manufacturers ship the product to a retailer DC, where it is unloaded, broken down, and then shipped to the retailer's e-Commerce DC- where it can then be used to fulfill orders. This extra step produces longer lead times and mean that the retailer has to hold increased levels of inventory, resulting in significantly higher holding costs than before. Due to these associated costs, retailers often choose lower stocking levels, which can result in lost sales. This is assumed to be a particular issue during peak holiday seasons and for high-value SKUs that incur higher holding cost (CPG Partner Company, Personal Communication, 2015).

2.4 Drop shipping model

To address this potential challenge of lost sales, some retailers are exploring using drop shipping for certain product categories. In this model, a customer places an order on the e-tailer's website and the manufacturer ships the product directly to the customer's door. In a pure drop-ship model, the retailer carries no inventory and only transmits a purchase order to the manufacturer who fulfills it, creating what researchers Randall, Netessine and Rudi call a "virtual supply chain" (Randall, Netessine, & Rudi, 2002) (see Figure 2-1) . CD retailer Spun.com was able to achieve savings of around $8 million by shifting its inventory to its distributor Alliance Entertainment (Gordon, 2000).

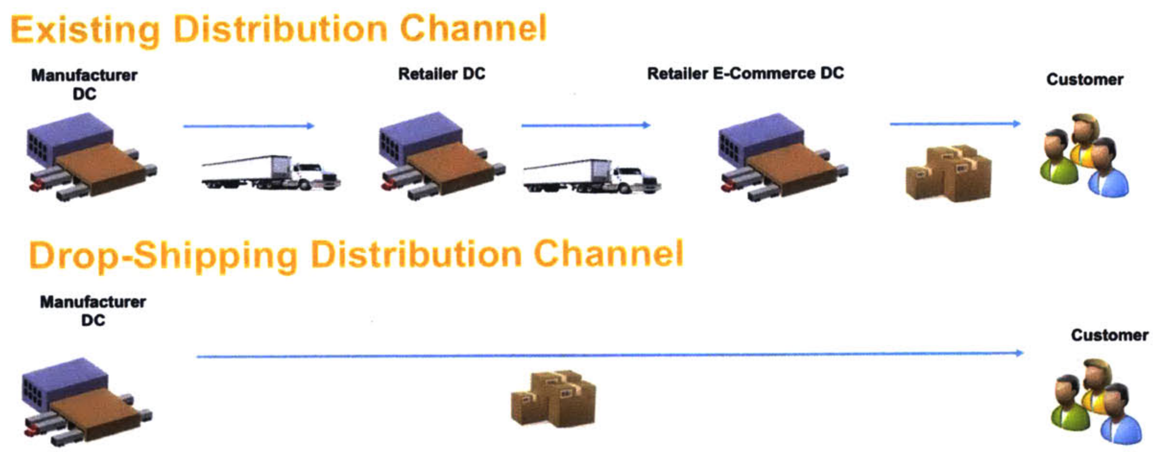

Figure 2-1: Comparison of existing and drop shipping distribution model

According to a study by Bailey and Rabinovich (2005), over 55% of CPG manufacturers claim that online retailers have inquired about drop ship capabilities. Manufacturers are wondering if drop shipping can be an effective alternative to other contract solutions aimed at solving inventory-holding issues (e.g. lower wholesale prices during holiday seasons, buyback contracts).

2.4.1 Drop shipping benefits to retailers

Much of the current research in the drop shipping area relates to the benefits to the retailer. According to Li, Tu and Guo (2011), retailers that rely on manufacturer drop shipping to fulfill their orders experience significantly lower holding and handling costs. This is because they once had to receive all of the product from the manufacturer into their own distribution center, store it, pick, pack and ship to customers. In the new model, they can pass all of those responsibilities to the manufacturer, allowing the retailer to focus on marketing and advertising. It also allows retailers to offer a broader product variety with little risk (Randall, Netessine and Rudi, 2006) and increase profits from capturing potential lost sales.

2.4.2 Drop shipping benefits to manufacturer

Most of the literature frames drop shipping as a retailer focused tool and doesn't explore all of the potential benefits of drop shipping from a manufacturer's perspective. Some research shows that drop shipping can achieve significant gains for the manufacturer with regards to revenues, inventory holding and handling cost and negotiation power. Yu and Deng, for example, confirm that the usage of a drop-ship model can help manufacturers increase revenues by capturing lost sales and reduced advertising expenditures for suppliers (2013).

Chopra and Meindl (2007) suggest that the consolidation of inventories from multiple retailers at the supplier or manufacturer – known as risk pooling - results in better visibility in forecasting and the ability to provide high availability at lower inventory levels (Chopra & Meindl, 2007). The aggregation of inventory at the manufacturer can also often reduce inventory handling cost, although consideration needs to be given to the additional cost resulting from the re-packaging of full cases to individually packaged items (Chopra & Meindl, 2007).

Another interesting benefit to the manufacturer is the shift in negotiating power that occurs. Rabinovich, Rungtusanatham and Laseter (2008) note that because the customer delivery experience is so crucial to an online retailer's success, drop shippers have stronger bargaining power than retailers. It's easy to see how this advantage in negotiations can be exploited. With the new drop shipping model, the manufacturer is now paying for the distribution cost to the customer, and as such, it will be able to re-negotiate the per-unit wholesale cost that they charge the retailer to account for this new expense and potentially an additional margin leading to increased profits. Empirical evidence for this phenomenon has been shown by Scheel (1990).

2.5 Estimating lost sales

One of the key advantages from drop shipping from a manufacturer's perspective is the potential to capture lost sales. However, it's very difficult to estimate the impact lost sales have on a business. Even for retailers, who have both Point-of-Sale (POS) and inventory availability data, estimating lost sales can be complex because unmet demand goes essentially unobserved (Agrawal & Smith, 2015). There have been a number of techniques that have been used in research to account for this unmet demand. In the case where demand distribution is known, lost sales can be estimated using classic inventory theory as seen in Zipkin (2000). When demand distribution is unknown, Conrad (1976), Anupindi et al (1998) and Nahmias (1994) have used Maximum Likelihood Estimation (MLE) for their lost sales estimations. MLE uses an existing data set to choose the values of a given number of parameters in a model that maximize the likelihood of these being accurate (Agrawal & Smith, 2015).

The challenge with many of these techniques is their reliance on data availability. Manufacturers are at a disadvantage from a data perspective. They have both limited POS data from their retailers and virtually no visibility to retailers' inventory availability. This lack of data makes it difficult to estimate the impact of lost sales.

It's possible that information technology can help manufacturers solve this lack of retailer-side inventory information. Almost all e-Commerce stores display some sort of product availability information (in stock, out of stock etc.) on each product's webpage or somewhere in their online store. For firms with a broad product line and multiple retail partners, collecting this data by hand from each product's page daily would be a monumental task.

It is possible that a group of tools that are currently being widely used in other business intelligence applications could be adapted to enable the data collection. These tools are known as Web Extraction Systems. They are designed to automatically scour the internet, accessing pages with dynamic content. The tools can target specific data types, extracting them from each individual page and creating a database with the desired information (Baumgartner, Gatterbauer, Gottlob, 2009). They've emerged as a growing part of most firms' competitive intelligence arsenals in the modern business environment and can be customized to focus on specific tasks (Ferrera, De Meo, Fiumara, Baumgartner, 2014).

This type of information extraction from the internet has been applied in the retail context before to look at inventory levels. Dewan, Freimer, & Jiang (2007) explore how retailers can use these techniques to monitor competitors' inventory positions, dynamically raising prices during supply shortages to maximize profits. Their research demonstrates that this retailer inventory data is extractable and can be used as an approximation to better understand trends in stockouts.

Lastly, one needs to take into consideration that the effect of stockouts goes beyond lost sales. According to a report by Procter & Gamble (P&G) from 2007, "a variety of strategic and operational costs apply to both retailers and suppliers including decreases in store and brand equity and attenuated impact of promotions and trade promotion funds. Out-of-stocks create a ripple effect by distorting demand and leading to inaccurate forecasts " (Gruen, Corsten, & Grocery Manufacturers of America, 2007). The complexity surrounding a consumer's experience with stockouts necessitates careful considerations by both manufacturers and retailers alike.

2.6 Impact of delivery time on customer purchasing behavior

The above discusses drop shipping's impact on the manufacturer and the retailer. However, any potential effect on the customer's experience must also be considered. In most aspects of the e-Commerce transaction there will be no difference to the customer, although delivery times may vary based on the facilities where the manufacturer would establish drop shipping capabilities. In their study on online customer satisfaction Schaupp & Belanger (2005) and Anand (2007) show that the minimization of delivery times plays an important role in purchasing behavior and customer satisfaction. Furthermore, online customers are increasingly demanding shorter lead times since they see themselves as "time starved" (Collier & Bienstock, 2006) - the ability to fulfill these time frames plays a critical role when deciding whether an item should be fulfilled by the manufacturer.

3 Methodology

This section elaborates on the methods and estimations used to develop the framework applied for this thesis.

3.1 Project scope

3.1.1 Product and time period selection

As highlighted in the literature review, drop shipping is a particularly attractive option for high-value SKUs with high holding costs that experience significant spikes in demand. These products show the most promise of capturing previously lost sales. The thesis focuses on two specific high-value personal appliance product categories. From these two categories, we selected the 12 fastest moving SKUs, which experience almost 80% of their annual volume during the holiday season. We also limited the selection to SKUs with high retail prices[2] as these would have significant impact in terms of holding cost, hence a greater risk for experiencing stockouts and a greater potential in terms of capturing lost sales. In order to maintain anonymity, SKUs were named using a combination of their product category (A or B) and a numerical value (1, 2, 3…). We only considered the primary holiday season from September through December to reflect the CPG manufacturer's focus.

3.1.2 Fulfillment center selection

The CPG manufacturer already has an existing facility that is currently running a small consumer shipping operation and has consumer parcel shipment capabilities. We focused the analysis on utilizing this current operation to handle all of the projected drop shipment volume. Therefore, we did not explore the capital costs of building a new facility.

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[2] Exact price threshold withheld to protect partner's anonymity

3.1.3 Retailer selection

Similarly, to limit scope, we focused on one retailer where the CPG manufacturer's products are sold. The retailer is one of the CPG manufacturer's largest sales partners and has physical stores as well as a large online customer base. We simulated transitioning 100% of e-Commerce orders on the selected SKUs at the retailer to fulfillment with manufacturer drop shipping.

3.2 Data sources and manipulation

The research used data gathered from the CPG manufacturer's internal databases and data from a Web Extraction System externally acquired by the CPG manufacturer. The information provided was complemented by interviews with the existing distribution facility's leadership team as well as leaders from the e-Commerce supply chain team at the manufacturer.

3.2.1 Data sources

The following data sources were used in the analysis:

- **Detailed data for the CPG Manufacturer's existing drop shipping operation including:**
    - Customer volumes (orders and lines) being processed by the existing facility
    - Labor cost (fully-loaded cost for current Full-Time Employees (FTE))
    - Labor productivity measures (units per hour and effectiveness) for processing activities such as picking, replenishment, audit and manifest, packing, receiving and put-away
    - Materials cost for packaging and labeling
    - Transportation cost data from existing parcel operations to estimate average cost per package and total transportation cost
- **Cost data for current distribution model:** The dataset provided information for the chosen product categories for:
    - Inbound and outbound processing costs
    - Transportation cost to retailer's e-Commerce DC

- **Outbound shipment data:** Historical outbound shipment information for the selected product categories to the chosen retailer during the selected time period (provided by manufacturer).
- **Daily POS data:** Approximately 11,000 records of unit sales data for the chosen SKU sample sold through the retailer's e-Commerce platforms. The data covered the time period from January 2015 – December 2015. Each record represents the unit sales quantity of a single SKU on a given day.
- **Web Extraction System data**: Output from an online web extraction system including approximately 10,800 records. Records only include data for the two chosen product categories sold on the chosen retailer's website recorded on a daily basis. Each record contained information on the name of the product, its Universal Product Code (UPC) and its availability on the retailer's website on a given day between May – December 2015.

3.3 Activity-Based Costing (ABC)

In order to assess the cost associated with drop shipping, we utilized Activity-Based Costing (ABC). ABC is a common method used to allocate indirect costs based on distinct cost drivers for individual processes or activities. This is in contrast to financial accounting, which allocates indirect costs with a simpler approach that does not effectively capture operational differences that are critical for this analysis.

Using data from existing drop shipping operations and historic POS data, we built a model that calculated the costs for drop shipping all orders of the two personal appliance categories from the retailer's website between mid-September to December. The model only considered the variable cost per order incurred rather than any fixed cost associated with the operation. This cost was then compared with the existing variable cost for fulfilling orders in the current system. Below we outline the process and activities that were considered in the model.

3.3.1 Process Map

The process to drop ship a SKU is mapped out in Figure 3.1 below.

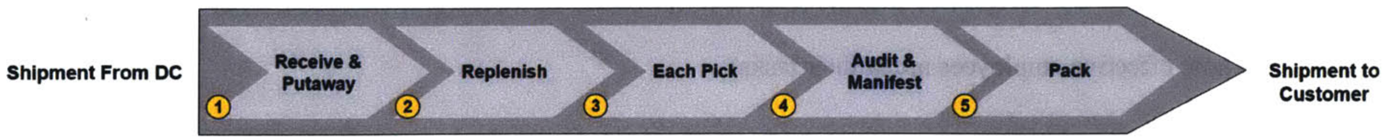

Figure 3-1: Process Map

3.3.2 Activities

The incremental cost of adding volume to the current facility was calculated per line item shipped.

Using ABC, the incremental indirect costs[3] were assigned to the following activities:

1. *Receiving/Put-away*: The receiving and (if required) breaking of shipments into cases arriving from within the co-located mixing center or other manufacturer-owned mixing centers. The cases are put away in a separate co-located inventory storage area specifically designated to drop shipping operations.
2. *Replenishment:* Process of replenishing cases from the co-located inventory storage area to a picking area with racks.
3. *Each Pick*: The process of picking a line item from the racks in the picking area.
4. *Audit and Manifest*: The process of verifying whether orders included all line items and the printing of a manifest stating the contents of the order.
5. *Pack*: The process of packing the order into a corrugated box.

In addition to the processes outlined above, material costs (box and tape) were included in the model.

[3] Facility utilities and maintenance costs not expected to increase

3.3.3 Productivity measures

The activities above can be divided into two primary categories: packaging material cost and labor cost. Labor costs are determined primarily by labor productivity (units processed per hour) and effectiveness (how effective employees are at their tasks).

Measures for labor productivity and effectiveness for different activities were based on observations and data obtained from the CPG manufacturing company.

Table 3-1: Productivity measures per activity in drop shipping

Cost Driver (Units of Measure)	Units per Hour	Effectiveness
Receiving and Put-away (Inbound Cases)	20	0.78
Replenishment (Inbound Cases)	60	0.78
Picking (Customer Sales Unit, or Each)	125	0.78
Audit and Manifest (Outbound Packages)	50	0.78
Pack (Outbound Packages)	80	0.78

3.3.4 Base model assumptions

The model was developed under a number of restrictions/assumptions. These include:

- *Lines per order:* It was assumed that the average number of line items was 1. Given the high value of the SKUs it was likely that consumers would only order one unit at a time. The CPG manufacturer validated this assumption.

- *Inbound case size*: To calculate the average number of units per inbound case we used the weighted average (by order volume) across all SKUs considered. This resulted in an average of 2.57 units per case.
- *Drop shipping process:* We assumed that each inbound case coming into the warehouse follows the process outlined in Figure 3-1. In reality, a small portion of the cases would be placed directly on the racks in the picking area without first going to the co-located inventory storage area.
- *Labor flexibility*: It was assumed that labor hours were flexible and new labor could be added instantaneously to exactly match needs. For example, if the model indicated a need for additional 0.3 FTE this could be added without consideration of full-time or part-time hiring capability.
- *Labor Week*: We assumed a standard 40-hour workweek for each FTE.
- *Labor Rate*: A fully-loaded labor rate of $22.00 per hour was given by the CPG partner company.
- *Material Cost*: Materials used in the process included standard 11 x 6 x 4 inch corrugated box, estimated at a cost of $0.73 and tape at a cost of $0.06 per package. If the lines per order exceed 1, then the model can account for the larger box size as necessary, substituting an appropriate proportion of 18x12x11 boxes which cost $1.16 each with a tape cost of $0.08.
- *Transportation:* It was assumed that all SKUs could be sourced from within the co-located DC and would not require transportation from another manufacturer DC in the network. It was assumed that the retailer would be responsible for shipping cost to customers and this was therefore not included in the model.
- *Sales:* The base model did not include the capturing of lost sales and only simulated transitioning 100% of e-Commerce orders currently fulfilled by the retailer.

3.3.5 Base model sensitivity analysis

In order to understand the impact of the assumptions, we conducted a sensitivity analysis modifying a number of the parameters.

Lines per order

The sensitivity analysis tested how varying the lines per order would change cost. This may be particularly interesting when looking at promotions (e.g. "buy one, get one half price"). Box sizes are adjusted depending on the number of line items processed.

Increased volume and Capacity Constraints

The facility in our study has ample space to be able to process up to 6000 lines a day, which is almost three times as the facility processes today. This is a fairly unusual case as most facilities would not have such underutilized space and would need to incur additional cost to add more volume to their operation. One of the drivers of drop shipping would be the capturing of lost sales, which would increase the total volume transferred in the base model. We therefore added different levels of incremental sales expected from capturing lost sales ('Holiday Factor') to test the capacity constraint.

Different levels of labor flexibility

The model assumed that labor could be hired instantaneously in any amount. We tested two different scenarios where labor could only be hired in increments of either 20 or 30 hours per week. This could be expected to be the case in companies where high levels of unionization prevail.

3.3.6 Existing cost

In order to understand the cost implications of drop shipping, we compared its projected cost with the existing fulfillment cost. Currently, the only activities conducted by the manufacturer in fulfilling e-Commerce orders are shown in Figure 3 -2.

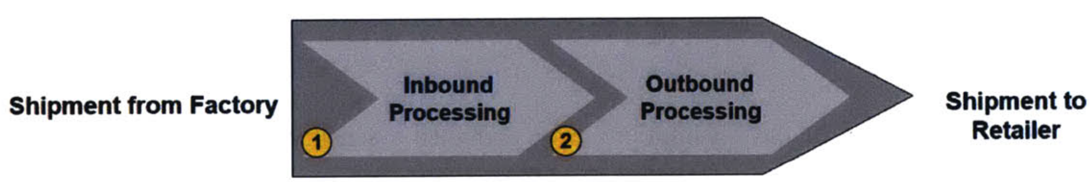

Figure 3-2: Existing fulfillment process

The activities shown in Figure 3-2 contain the following activities:

1. **Inbound Processing:** All administrative functions related to processing a full pallet received from the manufacturing plant including receiving and put-away.
2. **Outbound Processing**: All administrative functions related to preparing a full pallet for shipment including shrink-wrapping and truck loading.

The following productivity measures were obtained from the CPG manufacturer for the above process.

Table 3-2: Productivity measures per activity in existing fulfillment

Activity	Pallets per Hour
Inbound Processing	38
Outbound Processing	28

As in the drop shipping model, the retailer is absorbing transportation costs.

3.4 Total channel cost and cost allocation

3.4.1 Base model

To understand changes in overall channel cost and how these would be allocated, we compared the costs per unit in the current and the drop ship model. This demonstrated how the total channel distribution costs changed, and how each channel partner's costs changed in relation to each other. The latter is illustrated in Figure 3-2 and 3-3.

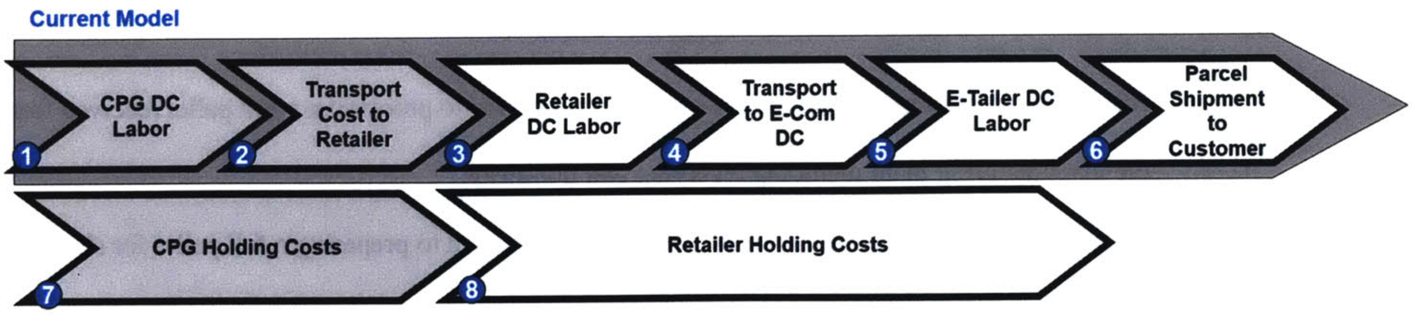

Figure 3-3: Cost items and cost allocation in current fulfillment model

Note: Grey Shading - CPG Manufacturer Black Shading- Retailer

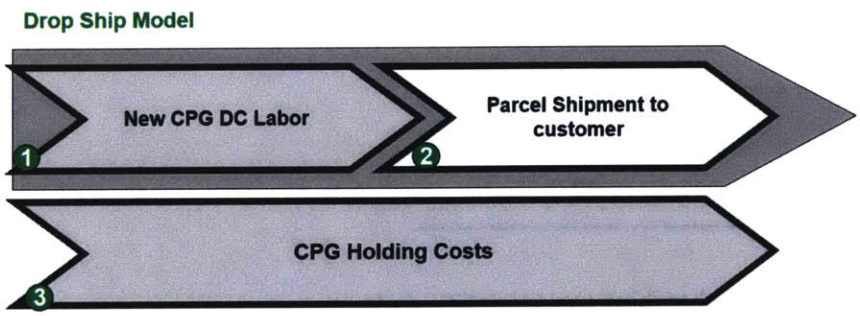

Figure 3-4: Cost items and cost allocation in drop ship model

Because we were only able to obtain data from the manufacturer, we had to estimate some of the retailer's costs.

In keeping with the cost factors outlined in figure 3-2 and 3-3, the following categories were included in the analysis:

1. *CPG DC labor* - This includes all the processing and labor involved in processing a unit at the CPG manufacturing company. This is equivalent to the existing costs described in 3.3.6.
2. *Transport cost to retailer DC* - This includes the transport of the unit from the manufacturer DC to the retailer DC.
3. *Retailer DC labor* - At the retailer, the pallet gets broken up and is separated into cases that remain in the Retailer DC and some that are moved to the e-Commerce DC.

4. *Transport from retailer DC to retailer e-Commerce DC* - Once broken down, the retailer ships the cases designated for e-Commerce to a nearby e-Commerce DC.

5. *Retailer e-Commerce DC labor and material* - At the e-Commerce DC, the cases are broken down into units, processed and shipped to the customer. The processing activities are similar to those analyzed in the drop-ship model (see 3.3).

6. *Parcel shipment to customer from e-Commerce DC* - This includes the shipment of the unit to the customer by a parcel delivery from one of the retailer's e-Commerce facility (paid for by the retailer).

7. *Retailer holding cost* - In order to provide a complete picture in terms of cost we also included retailer inventory holding charges for the time in which the units were stored within the retailers DC network (both the retailer DC and the e-Commerce facility)

8. *CPG holding cost* - Cost of holding inventory to fulfill retailer orders.

To draw a comparison between the two models the following costs were considered for the drop ship model:

1. *CPG DC labor and material in drop shipping* - This includes all the activities involved in processing units for drop shipping (see 3.3.6).
2. *Parcel shipment to customer from manufacturer DC in drop shipping* - This includes the shipment of the unit to the customer by a parcel delivery from the manufacturer's DC.
3. *CPG holding cost in drop shipping* - Cost of holding inventory to fulfill customer orders.

3.4.2 Working capital

In addition to comparing the distribution cost for the different models, we also looked at how these changes would affect the manufacturer's and retailer's balance sheets in terms of working capital. Working capital was estimated based on the average daily inventory that would be held by each party in the system.

3.4.3 Calculations and assumptions made in base model

The channel cost and cost allocation model was developed with the following calculations and under a number of restrictions/assumptions. These are detailed below:

- **Transport cost to retailer:** To calculate the transport cost to the retailer we used historical data from the manufacturer's transportation team. We estimated an average cost per shipment for the product categories to the retailer's distribution network to be $0.20 per unit.
- **Retailer DC labor:** As we did not have retailer DC costs, we used an estimate based on the manufacturer's distribution costs. These costs are comparable given that the manufacturer and the retailer perform extremely similar functions on full pallet level loads.
- **Transport from retailer DC to retailer e-Commerce:** To estimate the cost of transportation from the retailer's DC to its e-Commerce DC, the CPG partner company provided us with an estimated cost for full truck load shipments for a distance of 100 miles using their proprietary estimation formula. This represents the average distance between the retailer's DC and its e-Commerce DC. The cost is approximately $0.11 per unit.
- **Retailer e-Commerce DC labor and packaging materials:** To calculate the retailer's labor cost for preparing an individual unit for shipping we used an estimate based on the manufacturer's DC labor and packaging material costs and inflated the costs to $1 to account for the extra step of individual unit break packs to ship out the product.
- **Parcel shipment to customer from e-Commerce DC:** For parcel shipments, we used an estimate provided in the data from the CPG manufacturer and lowered it by 10% to account for the fact that the retailer receives lower rates due to their higher volume and they are shipping shorter distances out of multiple facilities. The cost for shipping a parcel was estimated at $5.0 per package.
- **Retailer holding cost in existing model:**
  - **Holding Cost:** We used the retailer's cost of capital to calculate the total holding cost. We only looked at the cost of capital because the products have long shelf lives and experiences low

obsolescence. This assumption was maintained when calculating the holding cost of the manufacturer. Cost of capital for the retailer was obtained from publicly available financial data regarding value of debt and equity and was estimated at 5.43% [Stock-analysis-on.net, 2016]. The total holding cost for the period was divided by total number of shipped units to get per unit holding cost.

- **Inventory Days:** Inventory days (the number of days a SKU spent in inventory) were calculated based on e-Commerce designated inbound shipments to the retailer and POS data. Using daily information for how much inventory entered and exited the system, we were able to estimate average inventory levels. For SKUs where no shipment data was available, inventory patterns for SKUs with similar sales patterns were applied.
- **Formula:**

$$H = \sum_{i=1}^{12} \sum_{k=1}^{119} \frac{C_i V}{365} \left[I_{ik} - O_{ik} + N_{i(k-1)} \right]$$

$$S = \sum_{i=1}^{12} \sum_{k=1}^{119} O_{ik}$$

$$\frac{H}{S} = \textit{Holding cost per unit shipped}$$

i= SKU

k= day (119 days total from 9/1/15 12/31/15)

C=wholesale cost ($)

N=day's starting inventory in units

H= Total Holding Cost

V= Capital cost %

I_{ik} = inventory receipts for SKU *i* on day *k* (inbound shipment qty in units)

O_{ik}=inventory outflow for SKU *i* on day *k* (Qty Sold in units)

S=Total Units Shipped

- **CPG holding cost in existing model:** To calculate the CPG manufacturer's holding costs we used the following data/assumptions:
  - **Holding cost:** We used the CPG manufacturer's cost of capital as obtained via the CPG partner (6%). For each SKU this was multiplied with its Cost of Goods Sold (COGS).

- COGS: Since only wholesale price to the retailer was available, we had to make an estimate what the actual COGS were. Based on a study conducted by consultancy PriceWaterhouseCooper (PriceWaterhouseCoopers, 2015), the median profit margin for CPG manufacturers is around 36%. We used a conservative estimate of 30% profit margin to approximate the COGS in this case.
- **Inventory Days:** Based on interviews with the CPG company's leadership, we used an average inventory turnover of 20 days. This means we assumed each SKU spent 20 days in inventory. We multiplied this with the total number of outbound shipments to the retailer.
- **Formula:**

$$H = \sum_{i=1}^{12} \sum_{k=1}^{119} \frac{C_i V}{365} * I_{ik} * T$$

$$S = \sum_{i=1}^{12} \sum_{k=1}^{119} I_{ik}$$

$$\frac{H}{S} = \textit{Holding cost per unit shipped}$$

**Where T=20*

i=SKU Number	V=annual capital cost (%/year)
k= day (Date from 9/1/15 to 12/31/15)	I_{ik}= inventory receipts for SKU i on day k (inbound shipment qty in units)
C_i=COGS ($) for SKU i	T= avg. inventory turnover period (days)

- **CPG DC labor and packaging materials in drop shipping**: We used the analysis from the ABC exercise described in section 3.4 to build a labor cost per unit for the CPG Manufacturer.
- **Parcel Shipment to Customer from manufacturer DC in drop shipping model**: We used existing data from the current drop shipping operations at the CPG manufacturer to estimate the base costs per package. This was then adjusted to account for the fact that the CPG company would use the retailer's

customer code, which would attain more favorable rates. Cost per parcel was estimated at $6.30 per package.

- **CPG holding cost in drop shipping:** To calculate the CPG manufacturer's holding costs we used the following data/assumptions:
  - **Cost of capital and COGS:** The same assumptions as made in the existing model were made to calculate the cost of capital and the COGS for the CPG manufacturer.
  - **Inventory Days**: In order to calculate CPG manufacturer's total inventory days we assumed an average inventory turnover of 51 days which was obtained through the manufacturer and validated by the company's most recent financial statements.
  - **Formula:**

$$H = \sum_{i=1}^{12} \sum_{k=1}^{119} \frac{C_i V}{365} * I_{ik} * T$$

$$T=51$$

$$S = \sum_{i=1}^{12} \sum_{k=1}^{119} I_{ik}$$

$$\frac{H}{S} = Holding\ cost\ per\ unit\ shipped$$

i=SKU Number	*V=annual capital cost ($/year)*
k=day (Date from 9/1/15 to 12/31/15)	I_{ik}*=inventory receipts of SKU i on day k (inbound shipment qty in units)*
C_i*=COGS ($) for SKU i*	*T=Avg. inventory turnover period (days)*

3.4.4 Channel cost sensitivity analysis

In order to understand the impact of the assumptions we conducted a sensitivity analysis modifying a number of the parameters. We also designed the analysis to show where the cost equilibrium was between the two models to answer the question: when does drop shipping becomes a better option than the current model?

Drop Shipping Parcel Transportation Costs

Because we only had data from the current manufacturer shipping operations, we recognize that there is uncertainty for this variable, which represents a large portion of the distribution costs. We expect the retailer to receive better rates- we will vary this cost to see how these changes impact the model.

Retailer DC Labor Costs

The retailer e-Commerce DC labor costs were estimated based on the CPG DC labor. In reality it could be significantly higher or lower, depending on the efficiency of the specialized each-picking operation that the retailer runs.

3.5 Lost sales estimations

As mentioned in the Literature Review, capturing lost sales has the potential to be a considerable revenue driver for a manufacturer and could provide a strong justification to move towards drop shipping. To attempt to measure lost sales we used an external Web Extraction System that was purchased by the CPG manufacturer. This gave us some visibility to critical inventory availability data that we would not have otherwise. The system uses an algorithm to extract data from the target retailer's web store. It is able to log the availability of the product on a particular website, and save this data to a database. There are 5 possible result categories:

- **In Stock**: The product is available for purchase on the website
- **Out of Stock**: The product is displayed on the website but not in stock
- **Marketplace**: The product is sold through a third-party provider
- **Not sold online**: The product is not displayed on the website
- **Void**: Incorrect product link

On occasion, no data were recorded on a particular day. We labeled these days as "No Data". In the majority of these cases, the Web Extraction System had not begun tracking the information for this product or experienced technical problems. The objective in using these data was to identify the magnitude of the impact of lost sales, and if we needed to account for extra unit volume in the drop shipping projections. For this purpose, we paired daily POS information with daily website availability information for each product across the peak holiday period.

3.6 Customer delivery time

To estimate approximate customer delivery times with the new drop ship service, we used a time-in-transit table calculator from UPS. We coupled this information with population density data to understand where the majority of orders would come from and to obtain a weighted average delivery time for the whole network. This gave us an indication of how quickly the CPG manufacturer could fulfill orders out of its only facility.

4 Data analysis and results

This section presents the results of the analyses outlined in the Methodology section. It serves to identify the cost associated with drop shipping and its impact on total channel cost as well as its distribution across channel actors. We also assess the presence of lost sales and the effect that drop shipping out of the existing facility would have on delivery time.

4.1 ABC analysis

4.1.1 Base model

The analysis from the base model showed that shipping a unit out of the existing facility within the given parameters resulted in a variable cost of $2.66 per unit. Figure 4-1 shows the cost breakdown per unit shipped.

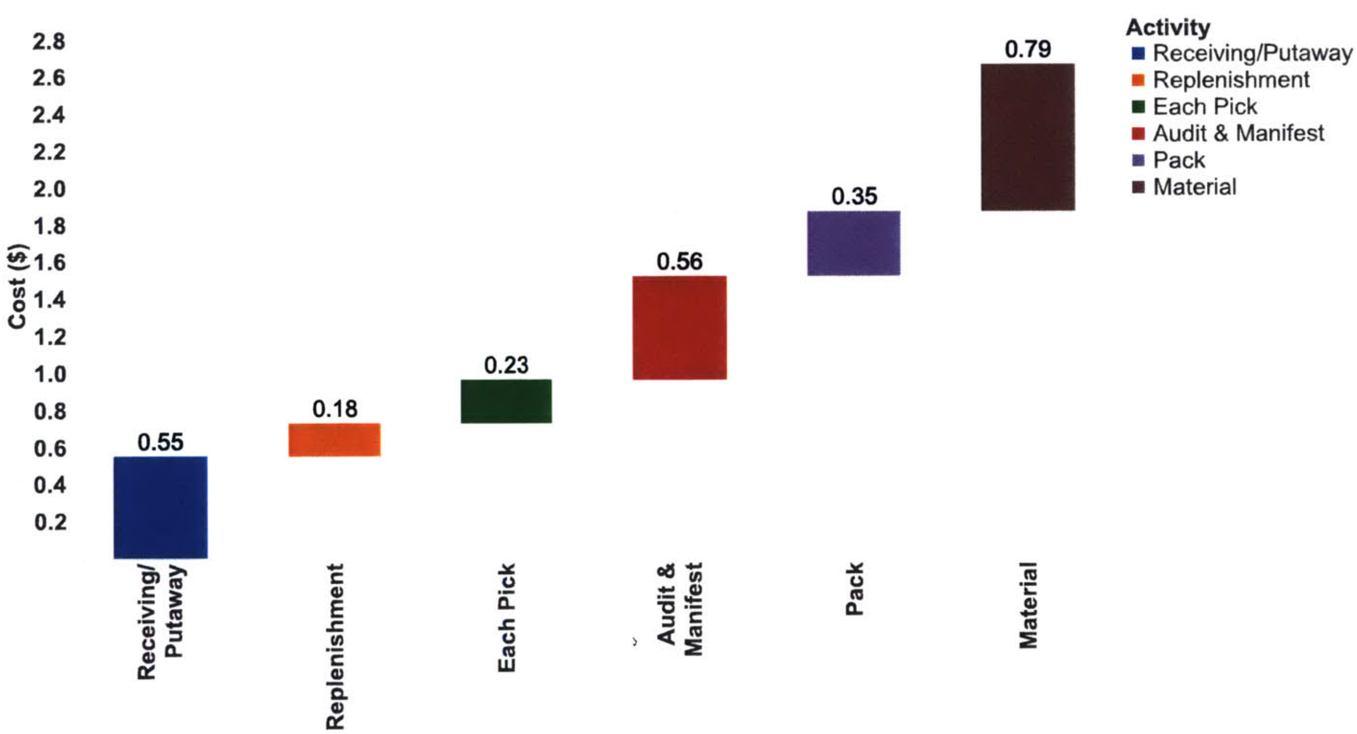

Figure 4-1: Cost break-down per unit

As Figure 4-1 shows this cost is largely driven by the high packaging materials cost (almost $.80 per unit). This is followed by put-away/receiving cost and audit and manifesting activities, which are $0.55 and $0.56 respectively.

4.1.2 Sensitivity analysis – model simulations

As elaborated in the methodology section, a number of assumptions were made in the base model. To understand the impact of changing these assumptions, sensitivity analyses were conducted based on varying the following three inputs in the model: (i) Lines per order (ii) increased volumes during holiday seasons (holiday factor) (iii) more restrictive hiring policies.

Lines per order

Changes in lines per order considerably change the cost of drop shipping a unit. As Figure 4-2 shows, this is driven largely by changes in audit & manifest, pack and material cost. The variable unit cost is 30% lower (packaging and material efficiencies) when doubling the lines per order.

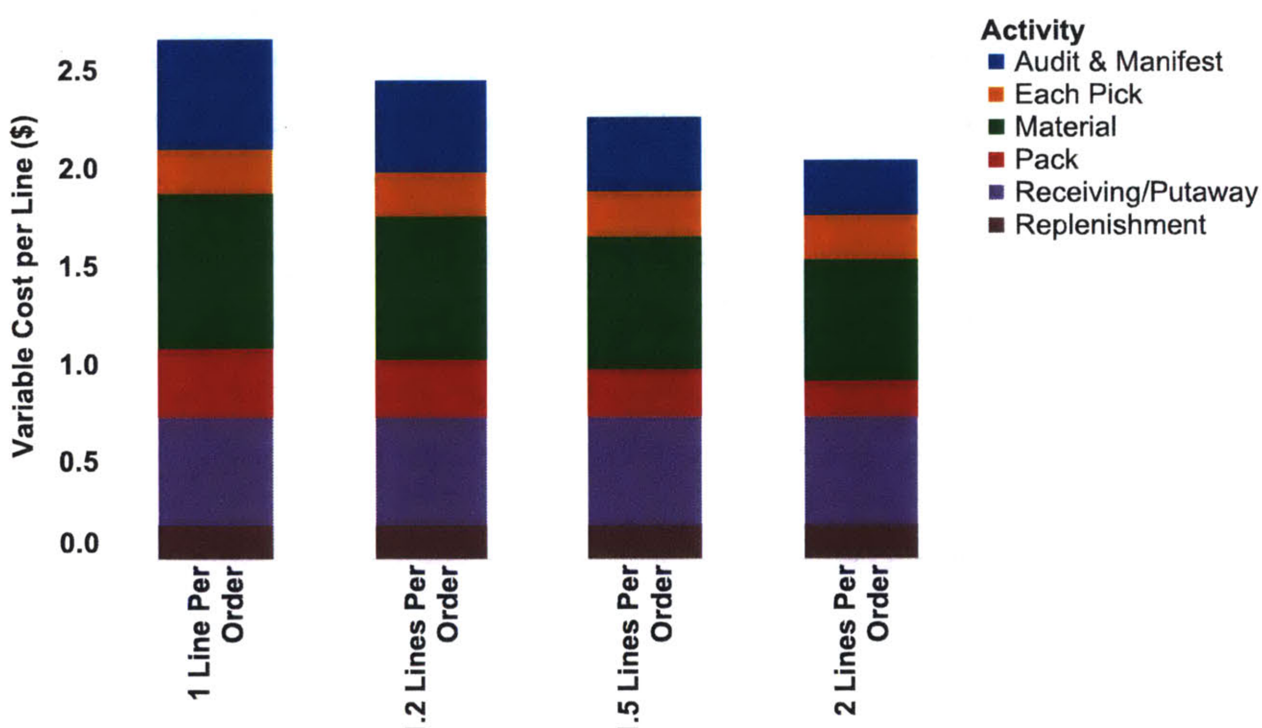

Figure 4-2: Lines per order sensitivity analysis - unit cost comparison

Increased volume during holidays ('Holiday Factor')

In the base model it was assumed that 100% of the volume being sold online would now be processed through the existing facility. However, the increased availability of the products could lead to fewer stockouts and the potential capturing of lost sales. The model therefore included a 'holiday factor' where total volumes for each of the months in the holiday season – October, November and December – could be adjusted. The reason for adjustment was less focused on the cost aspects of the model as it only calculates variable costs, which increase linearly, but to understand capacity constraints that may occur at the facility.

The current facility is able to handle up to 6,000 lines per day. Once this daily level is reached, the facility will not be able to handle any additional volume. The model showed that even with an increase of 10% of their current volume (during the peak months) capacity would not be reached. Only with an increase in sales volume by 38% of current volume in December (the highest volume month), the facility would experience capacity constraints.

Labor Flexibility

The base model assumed that labor could be adjusted instantaneously. In order to understand the sensitivity of the model to any restrictions in labor hiring policies we considered two scenarios. In the first scenario, new workers could only be hired in increments of 20h a week (50% of FTE work time). In the second scenario, workers could only be hired in increments of 30h a week (75% of FTE work time). The analysis shows that the total labor cost increases by 4% and the variable cost per unit increases from $2.66 to $2.73 when restricting labor flexibility to hiring at a minimum of 20h per week. A 10% increase in total labor cost and a variable cost increase from $2.66 to $2.85 can be seen when restricting hiring to 75% FTE.

4.1.3 Cost comparison with existing cost

To understand the cost implications of using drop shipping a comparison had to be made with existing fulfillment cost (see Figure 4-3).

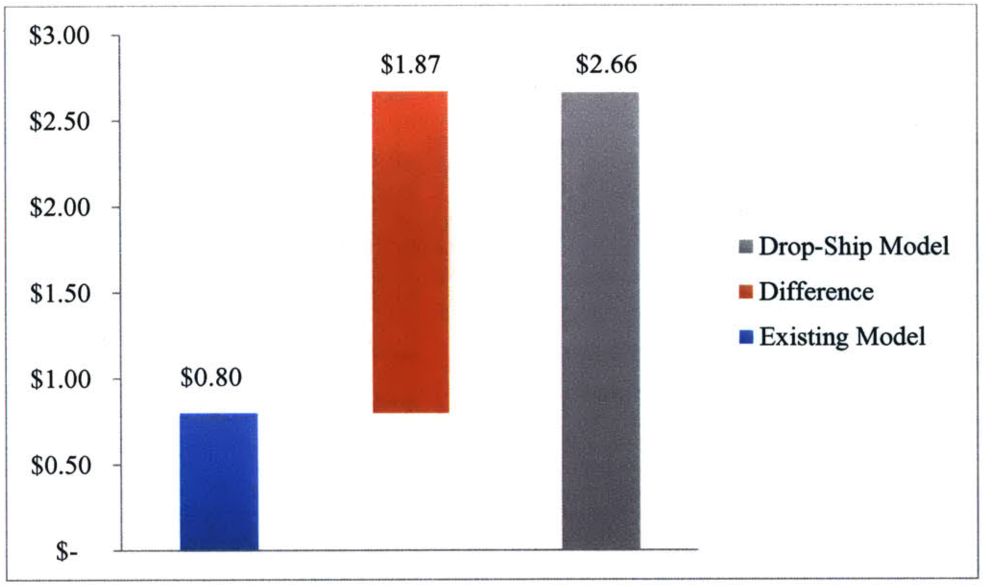

Figure 4-3: Cost comparison drop-ship and existing model

As Figure 4-3 shows, the cost difference between the current and the existing model is around $1.87 per unit shipped.

4.2 Lost sales

In order to understand the potential opportunities to capture lost sales using drop shipping, data from a Web Extraction System was analyzed and paired with POS data. Below we summarize some of the key insights derived from the analysis.

4.2.1 Category A stockouts

Online availability for four different category A SKUs was analyzed. For most SKUs, data availability was robust with the exception of SKU A4, which had no information for early October.

As Figure 4-4 shows, SKUs appear to be in stock for most of the high-demand season. This is particularly impressive for SKU A1, which is the fastest selling SKU in category A with over 12,000 items sold during the holiday season.

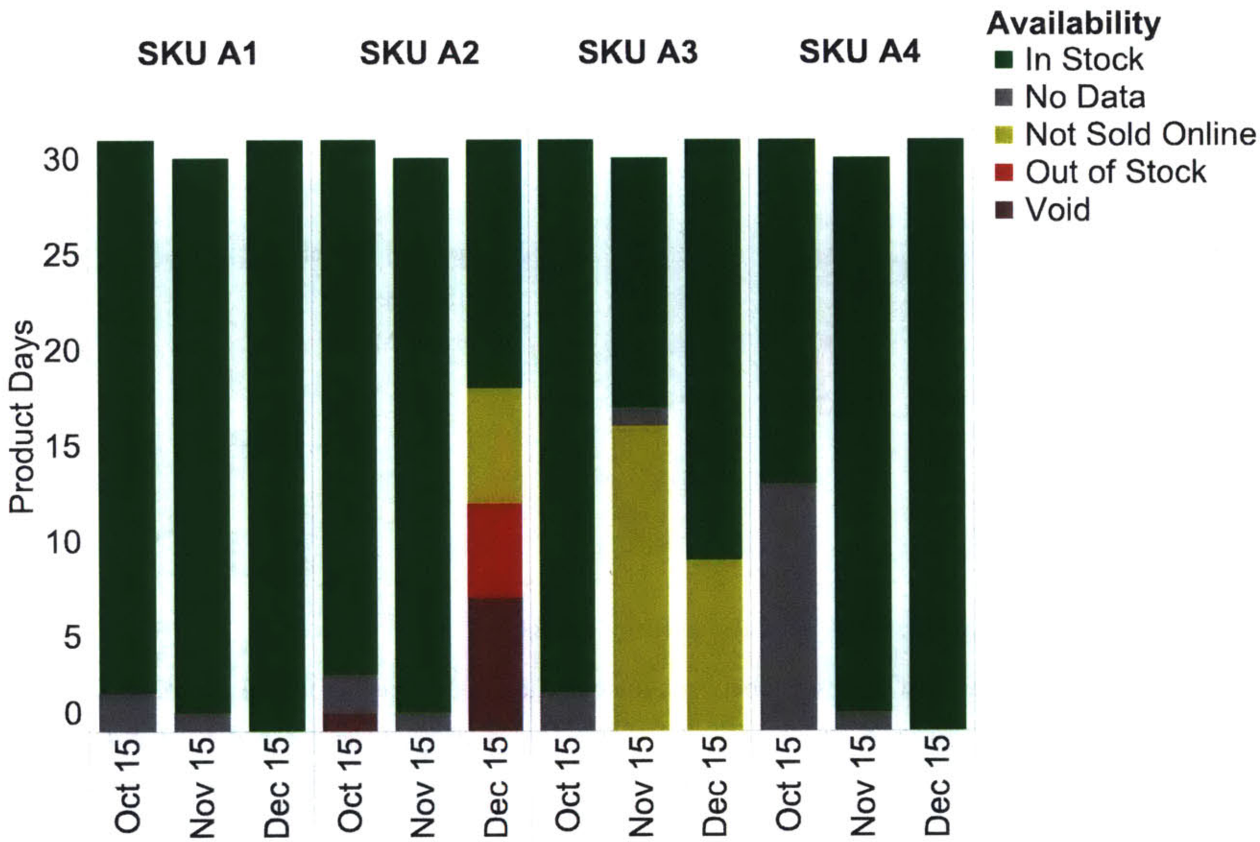

Figure 4-4: Breakdown of availability for Category A for daily samples taken in October, November and December

SKU A2 appears to have been stocked-out during a five-day period from December 10-15. On December 12, the SKU appears to be in stock before going out of stock again on the following day. SKU A2 became available on 'Marketplace,' which is the term for third party sales on the website, on December 16; this is possibly as a result of the prolonged stockout. SKU A3 experienced another incident in which it was flagged as 'Not Sold Online' for a number of days. This may signal an availability issue. SKU A2 and A3 will be further analyzed in Section 4.2.3.

4.2.2 Category B products

Online availability for seven category B SKUs was analyzed. Data availability was more limited for category B products - for all SKUs analyzed, data was only available from November 24th until the December 30th 2015. This is because the Web Extraction System only started tracking these SKUs in late

November. However, we believe that this is not a major issue. We verified with POS data that the sales peaks occurred after late November and are included in the Web Extraction Data set. A more detailed analysis can be found in Section 4.2.4.

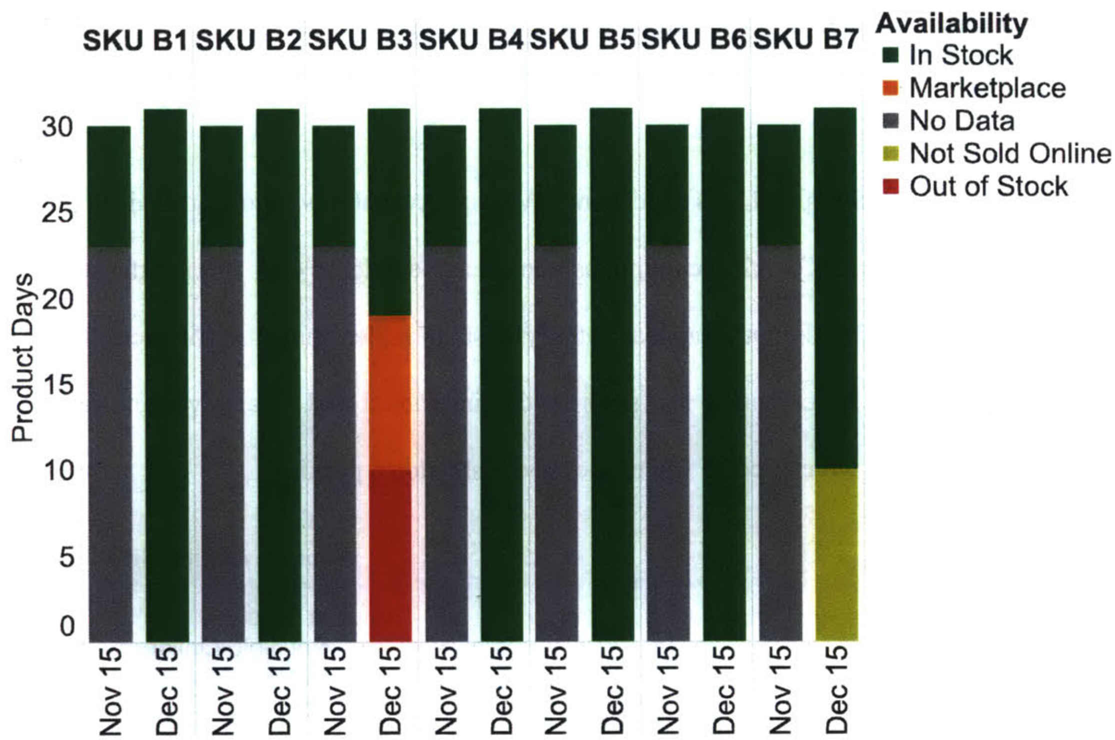

Figure 4-5: Breakdown of availability for Category B for daily samples taken in November and December

As Figure 4-5 shows similar findings were made for category B products. General availability was high for most category B SKUs. Particularly noteworthy is that SKU B2, the fastest moving SKU, shows complete availability throughout the period. An exception is SKU B3, which experienced a stockout between December 2-8, from December 11-12, and again on December 15. This points towards a potential opportunity to capture lost sales.

4.2.3 Analysis of SKUs experiencing stockouts or long period of "Not sold online"

In order to gain a better understanding of the potential impact of the stockouts that occurred in SKU A2 and the SKU B3, availability data was matched with daily POS data for online sales from the retailer. We also analyzed SKU A3, which is indicated as "Not sold online" for a prolonged period.

Analysis of SKU A2

The pairing of POS data ('Total Shipped Units Sold') and 'Website Availability' shows that during peak sales during the end of November, SKU A2 is continuously in stock (see Figure 4-6). During the stockout that occurs in early December, sales do not disappear entirely as small replenishments still occur. Overall it seems that there is a potential for capturing lost sales on this individual SKU. Sales volume falls flat during the period of the stockout, which occurs when sales levels should be peaking.

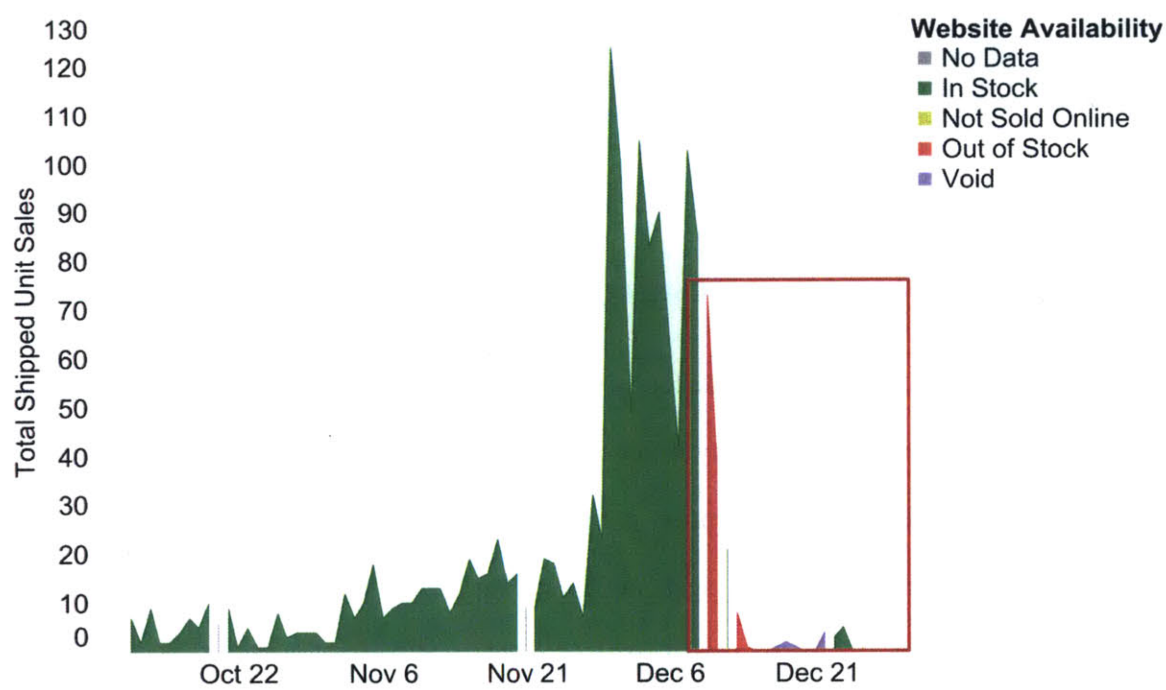

Figure 4-6: POS Data and Website Availability for SKU A2 October – December 2016

Analysis of SKU B3

SKU B3, displayed a prolonged period of out-of-stock followed by a switch to marketplace, perhaps due to a continued inability by the manufacturer to supply the SKU. The pairing with POS data confirms the assumption of a stockout. We see a complete loss of sales between December 2nd and December 19th (see Figure 4-7). The manufacturer indicated that it was general practice for retailers to move marketplace offerings to the top of the search results when the CPG manufacturer was out of stock for a prolonged period of time. Sales and availability appear to pick up again by the 20th of December, with good availability during that time. Although there is definitely potential to capture lost sales for this SKU, the low sales volumes of this SKU compared with other SKUs would not have a great impact on profitability.

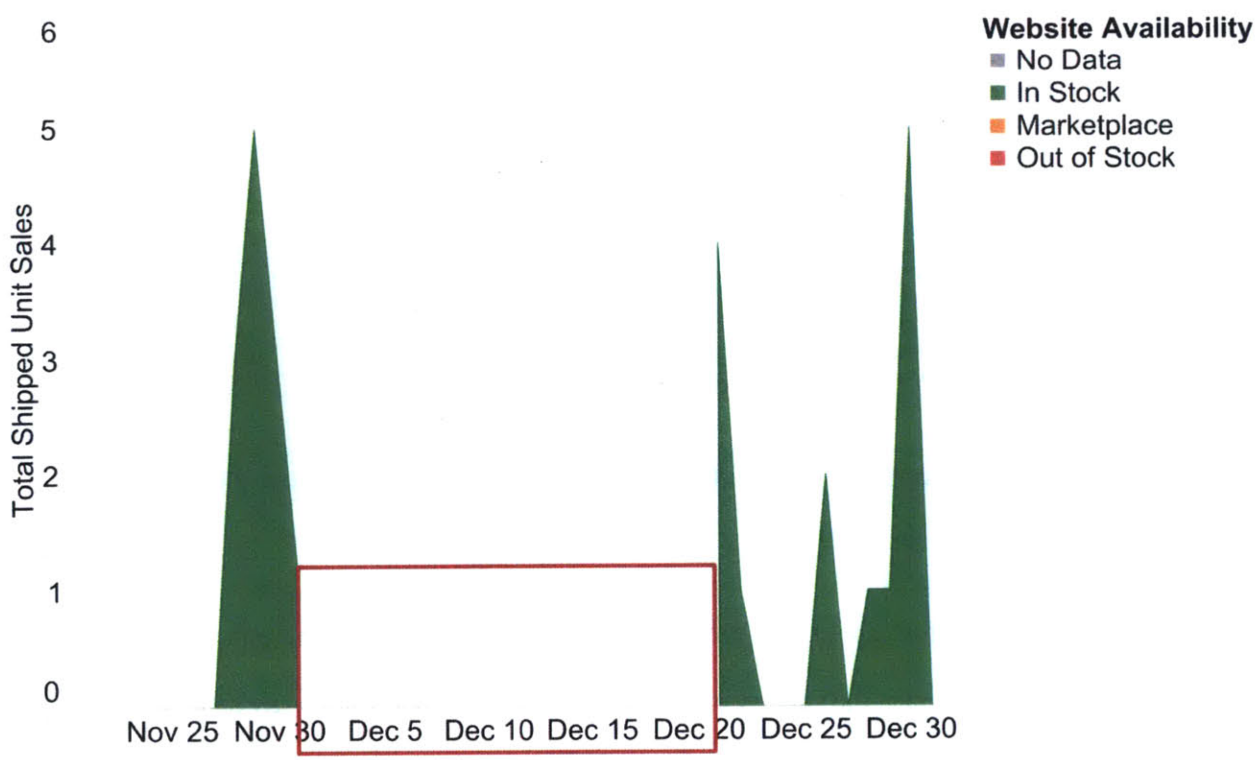

Figure 4-7: POS Data and Website Availability for SKU B3 November – December 2016

Analysis of SKU A3

As identified earlier, SKU A3 experienced a prolonged period of being designated as "Not Sold Online", which may indicate that the retailer had taken the product off the website due to lack of supply. When matching POS data with Website Availability, a considerable decline in units sold can be observed in the time period where the item was listed as "Not Sold Online". Interestingly however, the product is also shown as not available online on November 4th, when over 30 units were ordered online.

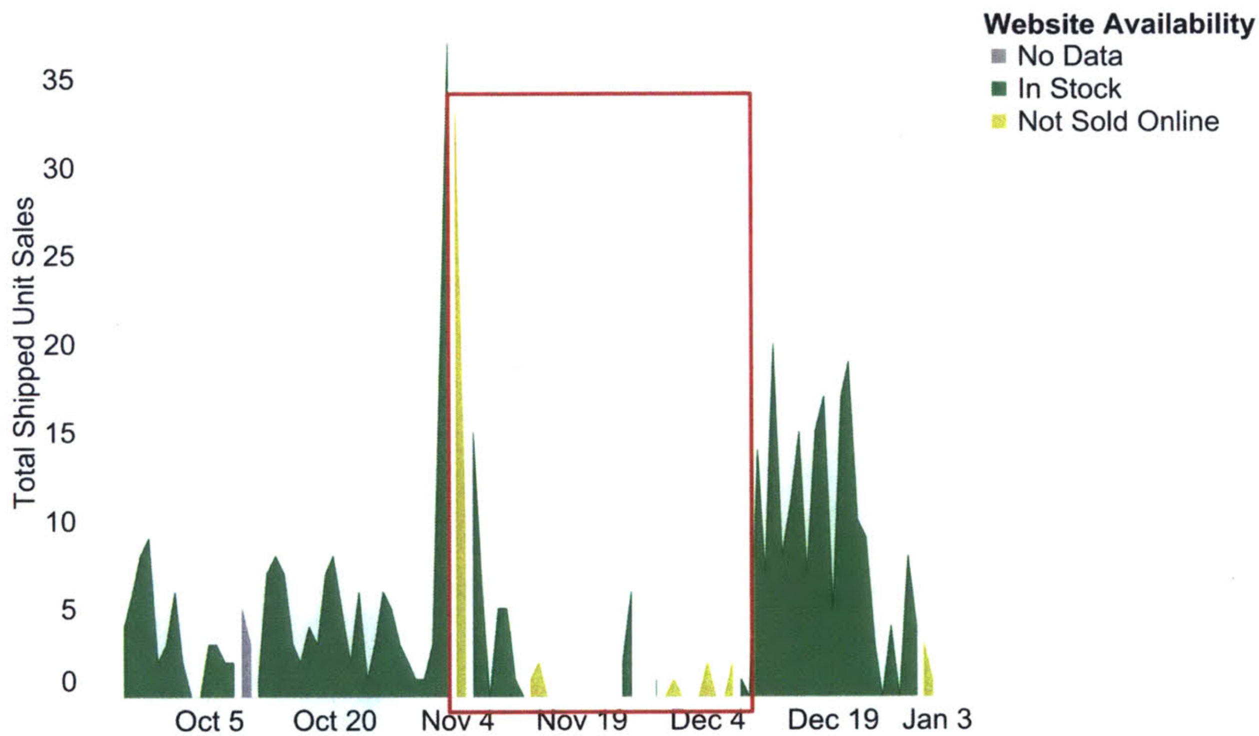

Figure 4-8: POS Data and Website Availability for SKU A3 October – December 2016

4.2.4 Limitations of Category B Data

As mentioned above, data for category B products was only available from the end of November to December. This potentially limits the validity of the analysis, as we cannot capture any data on availability earlier in the season where sales may also be high. To get a better understanding of the extent of this limitation we assessed POS data for the category B SKUs.

As Figure 4-8 and 4-9 shows, sales peaks for all category B SKUs only occurred in the period from late November to the end of December. This would indicate that the retailer is making significant efforts to ensure sufficient inventory during the peak season between late November and December. It also shows that the lost sales from a stockout prior to late November may have less of an impact.

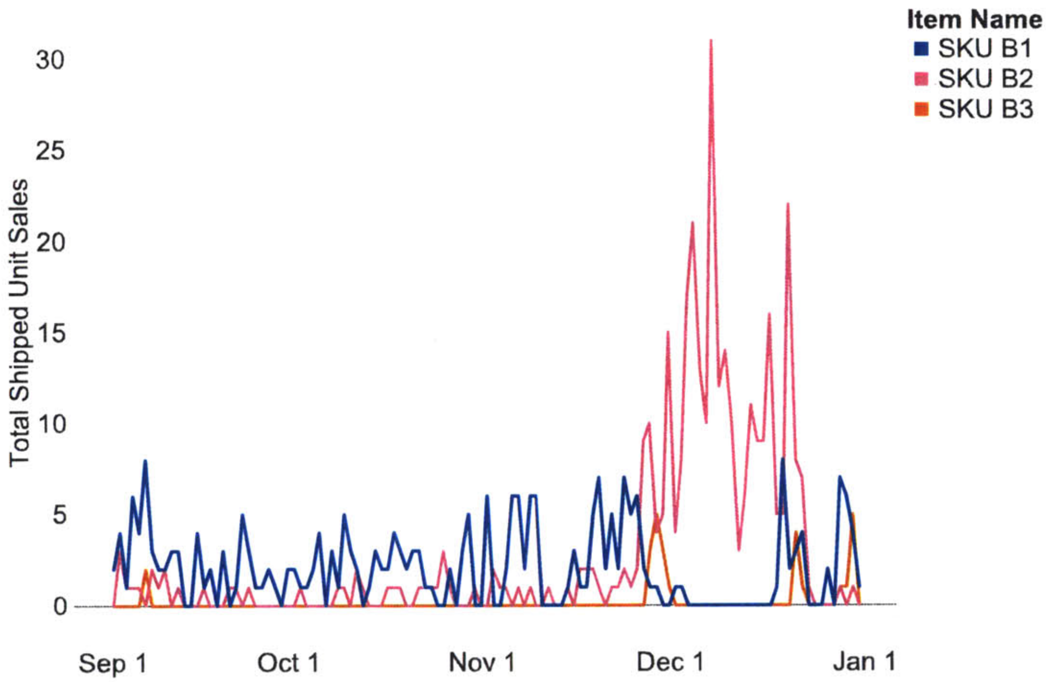

Figure 4-9: Sales data for SKU B1-B3

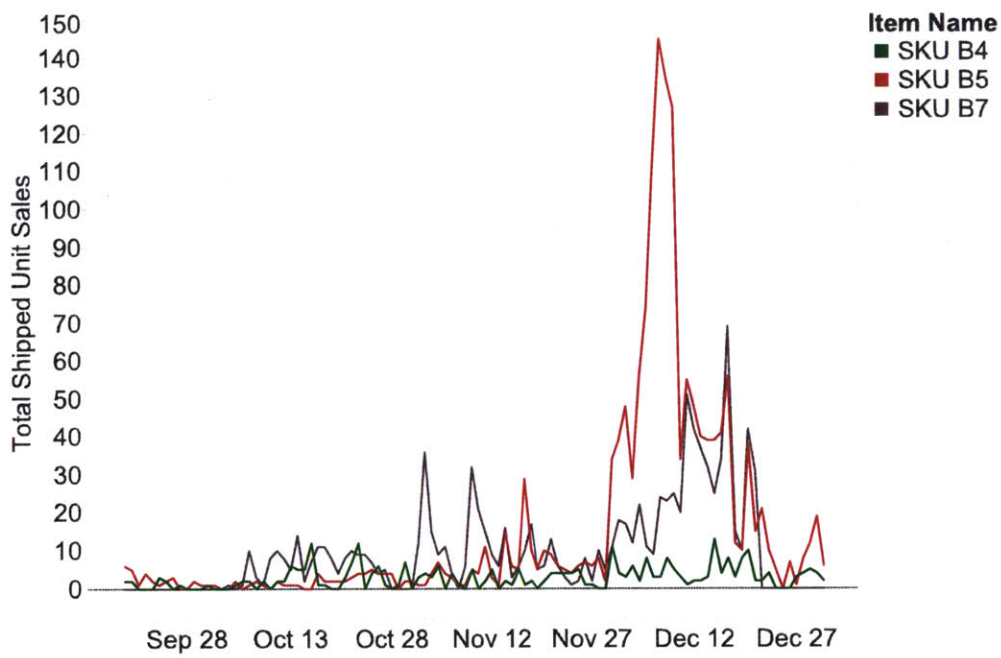

Figure 4-10: Sales data for SKU B4-B5, B7

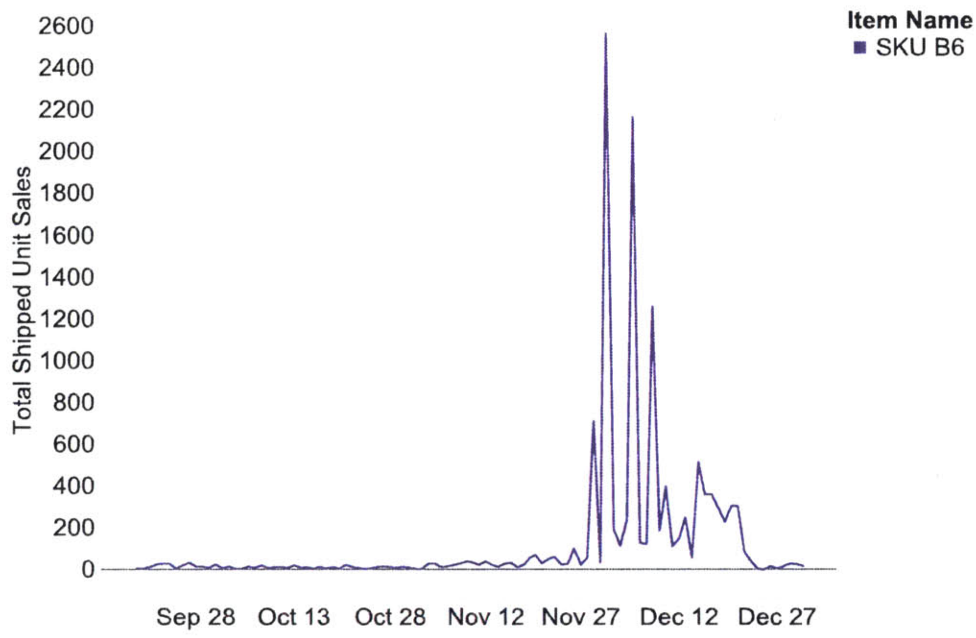

Figure 4-11: Sales data for SKU B6

4.3 Channel cost and cost allocation

4.3.1 Base model

The base model for the retailer and manufacturer pair and for the product categories that we analyzed shows that the channel costs will increase by 1.2% in a drop shipping setup (relative to the current model). Although the drop shipping model does succeed in eliminating several costs, including two separate transportation steps en-route to the retailer's e-Commerce DC, and labor at two separate retailer facilities, it still is a more expensive channel model overall. The high labor costs at the manufacturer's DC along with the single facility model (which drives up transportation costs) outweigh the savings from all of the removed steps in the supply chain.

The model also breaks down the cost allocation between manufacturer and retailer. In the existing fulfillment model, the CPG manufacturer is paying for 14% of the total supply chain costs, but in the drop shipping model, they assume responsibility for 37% of the total supply chain costs, which themselves have increased from $9.82 to $9.92. With the drop shipping model, the CPG manufacturer will incur $2.26 per/unit in incremental costs relative to the existing distribution model. This is in contrast to the retailer, who actually will save $2.14 in supply chain costs per unit. These shifts in cost allocations are shown in Figure 4-12. Table 4-1 shows a detailed breakdown of the costs in each model.

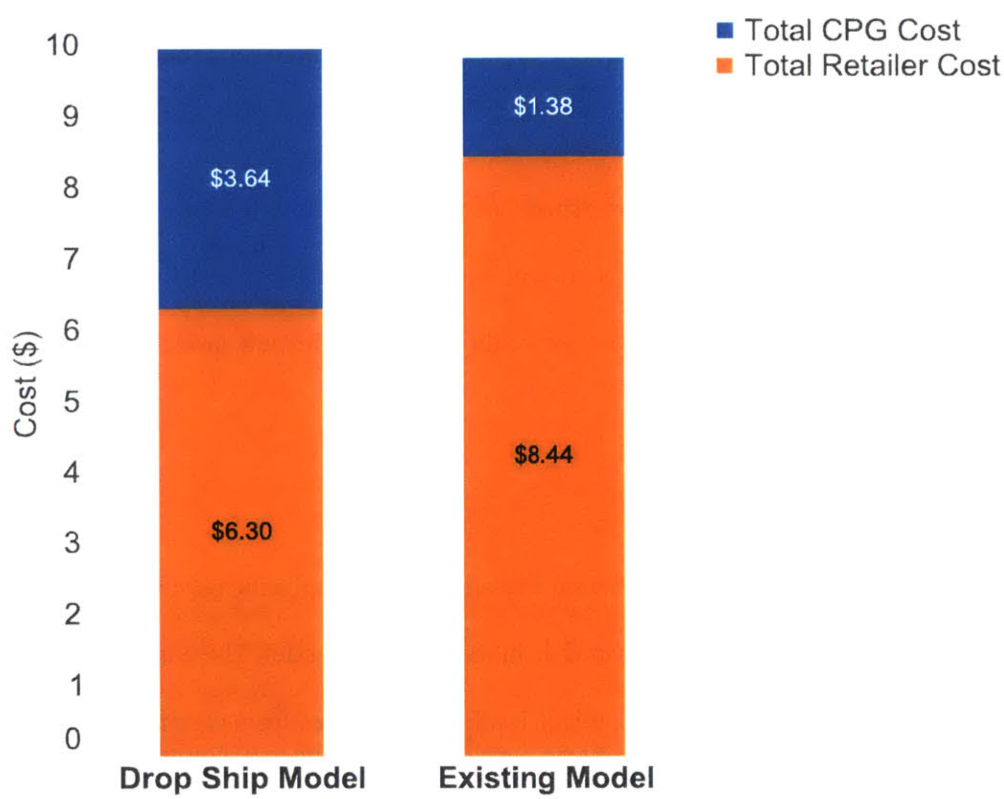

Figure 4-12: Comparison of channel distribution cost split in existing and drop shipping model

Table 4-1: Detailed per unit cost breakdown for existing and drop ship model

	Existing Model	Drop Ship Model
CPG DC Labor	$0.79	$2.66
Transport to Retailer	$0.20	-
CPG Holding Cost	$0.39	$0.98
Retailer DC Labor	$0.80	-
Transport to E-Com DC	$0.11	-
Retailer e-Commerce DC Labor	$1.00	-
Parcel Shipment to Customer	$5.00	$6.30
Retailer Holding Cost	$1.53	-
Model Total Cost	**$9.82**	**$9.94**

4.3.2 Sensitivity analysis channel cost allocation

In order to deal with the uncertainty of some of the estimations that we are required to make when calculating the retailer's supply chain costs in the current distribution model, we performed a number of sensitivity analyses. These analyses tested the impact of changes in transportation cost and retailer DC labor cost on the overall channel cost.

Changes in the parameters above impact two different aspects of the model. First, the combined overall cost of getting the product to the customer (channel cost) will change with the new distribution model. Second, it's also important to observe each party's allocation of the cost under the new model before there are any price negotiations or transfers.

Lower parcel rates

In the first sensitivity analysis we explored the case where the retailer, who pays for the parcel shipment in both models, actually has freight rates that are 10% lower than in the base case model. The base case model uses a rate of $6.30 per package for the drop ship model, which is a figure estimated from the manufacturer's current shipping rates for comparable volume (see 3.4.3). Given the far larger parcel spend by the retailer, a further reduction in this rate is very plausible. When lowering parcel rates by 10%, the drop shipping cost decreases by $0.63 and the drop shipping channel cost becomes $0.51 cheaper per unit than the per unit cost in the current distribution model.

Retailer e-Commerce DC labor costs

In the next scenario, we explore how the model reacts when the retailer's e-Commerce DC labor increases and decreases. Because the facilities that the retailer is distributing out of are designed for the sole purpose of 'eaches' parcel delivery to the final customer, it is reasonable that they can achieve a significantly lower per-unit labor cost than the CPG could performing the same work. We tested the case in which the e-Commerce DC labor is 50% more expensive ($1.50 per unit as opposed to $1 in the base case) but still significantly less than the $2.66/unit that the CPG would pay in the drop ship model. When increasing retailer DC labor cost from the base model, the drop ship model actually becomes less expensive than the current model.

4.3.3 Working capital shifts

Another critical factor in assessing the impact of this new fulfillment model is the extent to which a retailer can free up working capital when shifting inventory to the manufacturer. The analysis shows that by drop shipping items from the manufacturer and not tying up capital in inventory, the retailer gains around $3.28 million in working capital. However, on the other side, the manufacturer now needs to carry inventory to serve the customer orders and their working capital will increase by $1.19 million. Overall, with the switch to drop shipping, the total working capital in the system will be reduced from $4.05 million to approximately $1.97 million, an overall decrease of $2.08 million. The largest portion of the decrease in working capital is due to the difference in manufacturer COGS and wholesale price. In addition, the available data displayed poor inventory planning at the retailer. We found that the retailer is holding excessive amounts of inventory on very slow moving SKUs. This significantly increases their working capital requirements, working capital that the manufacturer would presumably be able to remove by carrying lower stock.

4.3 Lead time

Using information from the UPS website, we modeled how the estimated customer lead time for order delivery would change from the current model where the customer is served by the DC network of the retailer. We used a weighted average delivery time to each state, using the total state population as the weight (see figure 4-12).

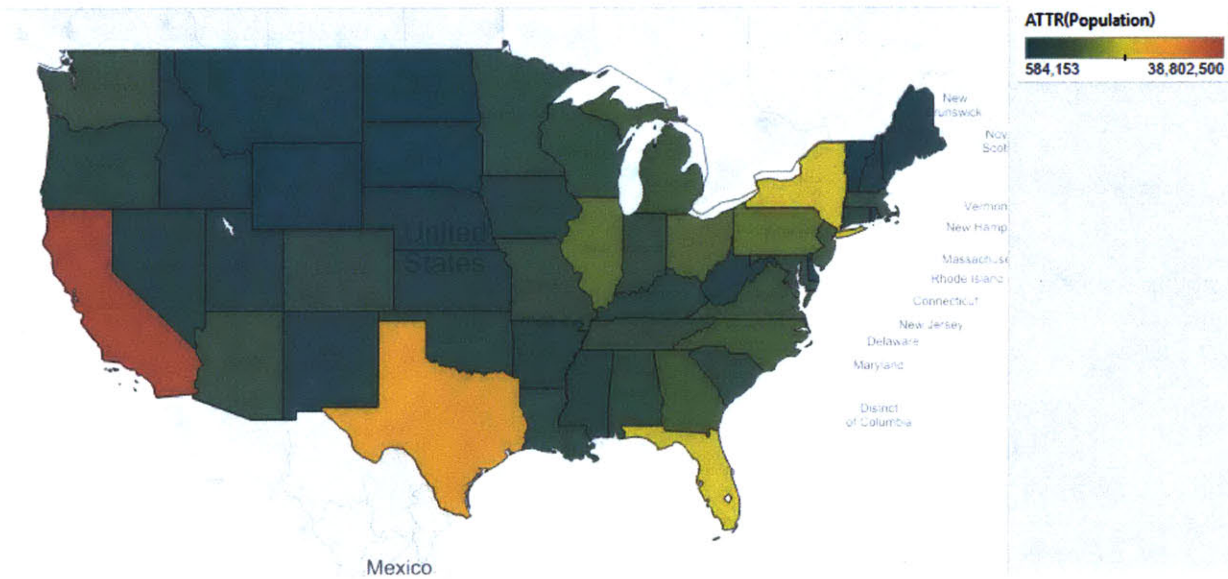

Figure 4-12: Population distribution by state map

The estimated lead time results for the current retailer's distribution network are shown in the map in Figure 4-13. The manufacturer projected lead times when adopting a drop shipping model can be seen in Figure 4-14.

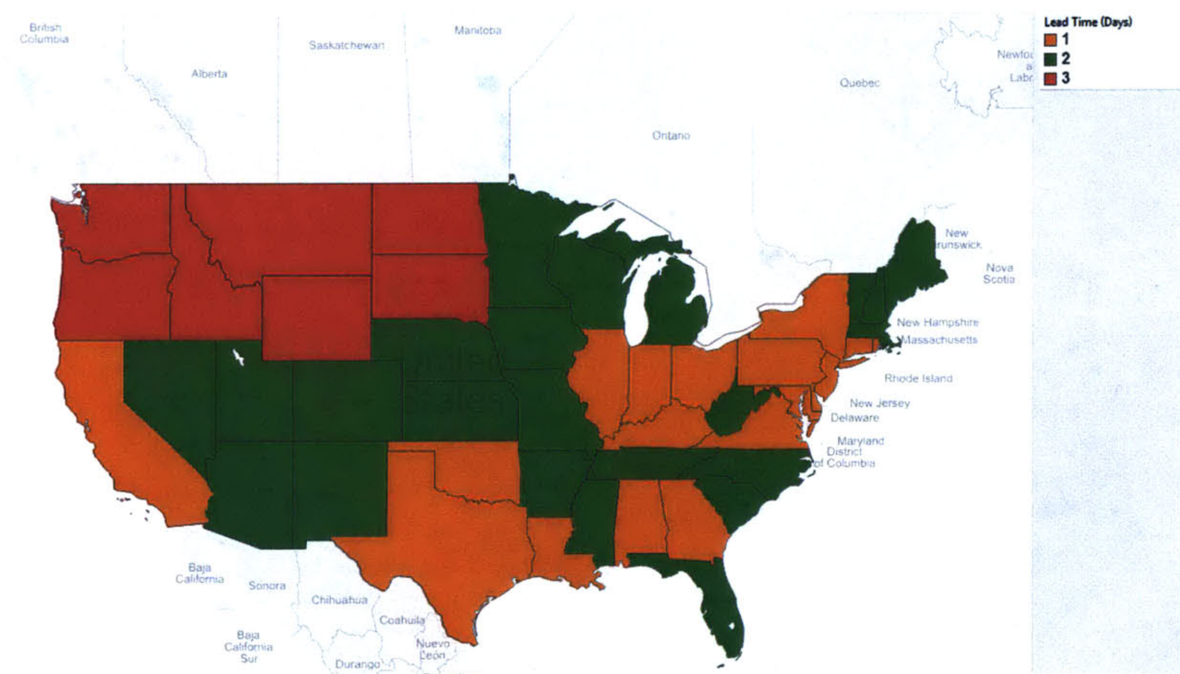

Figure 4-13: Estimated customer delivery lead times for current retailer distribution model

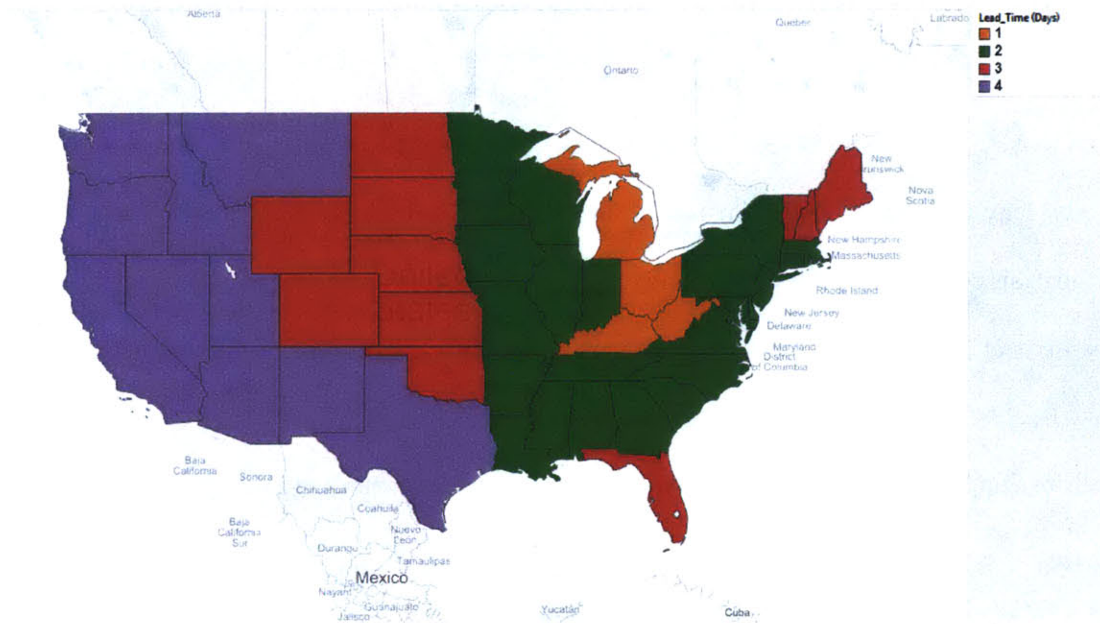

Figure 4-14: Estimated delivery lead times for the manufacturer drop shipping model

For the retailer's distribution network under the current model, the average parcel time in transit is 1.51 days. When we simulated the drop shipping model out of the manufacturer's single DC, we calculated an estimated weighted lead time of 2.67 days- over a full day increase for each customer. Also, under the retailer shipping model, 99% of the country can be reached in 3 days or less, whereas in the drop shipping model, a significant portion of the Western United States takes 4 days to deliver to.

5 Discussion

This discussion serves to interpret the results highlighted in the previous section and to elaborate on the implications they may have when a CPG manufacturer assesses the implications of implementing drop shipping. The analysis considers capacity, fulfillment cost, overall channel cost and cost allocation between the channel participants. Furthermore to assess whether these additional costs can be justified we use data from a Web Extraction System to gauge the extent of lost sales. Lastly, we will explore the potential ramifications drop shipping out of a single facility may have on customer service in terms of lead time.

As one of the first considerations in assessing whether to establish drop shipping capabilities, it is critical to understand the capacity requirements and processes involved in this fulfillment model. As the evolution of the e-Commerce business shows, new capabilities are required when shifting from handling pallets to shipping individual parcels. In the manufacturer's case, an existing facility was available to process parcels but had underutilized capacity. As the sensitivity analysis showed, considerable additional volume would be required in order to reach capacity within that facility. The potential additional volume that could be handled at the facility may even be higher as investments in more automated processes, which are not warranted at current volumes, could be made. Automation would have a particularly large impact on processing inbound shipments, which are very labor intensive at this stage. During on-site visits, we also identified a number of opportunities for non-technological process adjustments that could reduce labor requirements if the facility needed to processes large additional volumes of drop shipments.

The case of this CPG manufacturer is fairly rare in terms of underutilized capacity. Most companies would face some capacity constraint in their existing facility and would have to be clear what the implications are in terms of setting up a new space to handle the drop-ship volume. In addition, companies need to decide during which time periods they are willing to offer this service. When having to develop a new facility for drop shipping, offering this service only during holiday periods may not warrant this investment unless volumes and the potential to capture lost sales are very high.

When companies have very limited capacity to provide this service and are focused only on a specific time period in which orders are drop-shipped, alternative ways to deal with these inventory spikes and consequent capacity constraints should be investigated. As discussed with the CPG company's DC leadership, a potential process change is the implementation of pre-staged inventory. Because there are large numbers of homogenous orders during peak periods, boxes can be rapidly pre-packed in advance in anticipation of orders. In the manufacturer's facility, a special unit that prepares customized cases for promotions and merchandising could be well adapted to this purpose. This would ensure that the drop shipping volumes do not cause bottlenecks when added to already existing operations.

When looking at the cost side of the drop shipping equation, an Activity-Based Costing analysis proves to be a useful technique. Disaggregating cost shows the differences in labor usage between traditional and drop shipping fulfillment, highlighting again that fulfillment of individual units is a fundamentally different operation with different requirements and costs. It is important to understand both how this new model will change the supply chain costs (transportation, labor, and inventory holding) as well as working capital.

Shifting from the current model to the drop shipping model, the burden and costs of fulfillment are transferred from the retailer to the manufacturer. This transfer actually eliminates several steps from the supply chain. Because the product no longer gets shipped to the retailer's DC, then to the retailer's e-Commerce DC (before being packaged and sent to a customer), there are channel savings on both transportation and DC labor. Of course, these cost savings are offset by the increase in labor needed at the manufacturer DC to pick, pack and ship the orders as well as the higher transportation cost of shipping the end parcel out of a single central facility. In the end, we find that the two models are very similar in overall cost (with drop shipping being the more expensive of the two) but very susceptible to small changes in cost estimates (see 4.3.2). This is particularly true for parcel rates, which dominate the overall cost and, if negotiated well, can easily outweigh incremental labor, material and capital cost.

We also wanted to explore what would happen to the overall level of inventory in the channel as we switch from fulfilling out of multiple retailer DC's (five for the retailer) to one manufacturer DC. As we explore the results of the analysis, one of the main conclusions is that the retailer is actually holding very high inventory levels. Based on conversations with the CPG partner company, we were expecting to see poor availability during peak demand periods. What we actually found is that even during demand spikes, the chosen retailer's service level is extremely high. This is especially impressive when we consider the notable increase over normal sales levels the retailers experience during the holiday season.

Such spikes in demand necessitate that the retailer invests massive amounts in inventory, in this case exacerbated by the particularly high value of the SKUs analyzed. The analysis shows that by switching to a drop shipping model, the retailer could shed $3.28M in working capital, while the manufacturer would only need to invest roughly $2m in working capital to carry the same inventory. The difference in working capital has two contributing factors. First, the manufacturer is only tying up working capital for the COGS value of the goods, while the retailer's working capital covers the wholesale value of the goods. Second, according to the data on retailer shipments we identified that the retailer is grossly overstocking some slow-moving SKUs, which significantly drives capital cost. Poor inventory planning and longer lead times are assumed to be contributing factors to this.

In many supply chain applications, when consolidating orders from multiple locations to fulfilling from one distribution center, the concept of risk pooling would suggest that the centralized location would face reduced demand variability, and therefore would need to hold less inventory. However, we believe the risk-pooling will not have a significant impact on the level of on-hand inventory in the channel for a few key reasons. First, one of the assumptions for inventory reduction from risk-pooling is that customer demand is independently distributed. We expect that demand would be highly correlated across all locations during peak holiday periods. Additionally, we expect that the retailer uses a fulfillment policy that allows another facility to serve a customer order if that customer's primary facility is out of stock.[4] Therefore, when

[4] Because of this routing logic, we also may be underestimating the parcel transportation cost for the retailer to fulfill orders in the traditional model as they may not be shipping out the optimal location.

switching to the drop ship model, we do not believe that the warehouse on-hand inventory will actually change significantly from risk pooling, though future research could explore this further.

After covering how the overall channel costs change, it is important to realize what happens to each party's allocation of that total cost. In section 4.3, we saw that the manufacturer's cost burden has grown significantly. They are now responsible for more DC labor as well as holding all of the costs and risks associated with inventory in the system. The dramatic increase in the manufacturer's burden of the overall supply chain costs suggest that if they were to agree to provide this new drop shipping service, they should explore a contractual method to recover the extra costs incurred. When they are considering how to price this service, the manufacturer should remember both the incremental per unit distribution costs as well as the incremental working capital that they will be required to hold.

In this project, we were also able to demonstrate how Web Extraction Systems show promise in giving manufacturers visibility to their retailer's supply chain and gain a better understanding of the lost sales impact of stock-outs. While we recognize that there were some gaps in the data that the system provided, it still yielded useful information. Although the systems cannot currently document exactly how much inventory a retailer holds, when combined with other data sources, like POS data and outbound inventory data, manufacturers can begin to piece together the inventory situations at their retailers and make more informed decisions.

Lastly, the customer service level that can be achieved with this new service has to be assessed. Lead time is particularly critical for e-Commerce and it has to be carefully analyzed how the locations chosen to provide drop-ship fulfillment capacities affect these. In this case, fulfilling out of one facility increases the delivery time by one day on average. Some regions such as Texas being more affected, experiencing an increase in delivery time by 2 days. Because the current retailer provides shipping estimations in a range (4-7 days), this slight increase in delivery will likely not explicitly impact customer purchasing behavior.

6 Conclusion

E-commerce has significantly shaped the supply chains of retailers and manufacturers today. A frequent debate is who should hold inventory and fulfill orders in this system. In the traditional model, a retailer uses its own distribution network to fulfill customer orders. A manufacturer's role is simply to ship the products into the retailer's distribution network. However, businesses are increasingly questioning whether there are alternative ways to fulfill customer orders. An approach that is often explored is drop-shipping - where the manufacturer takes on the responsibility of shipping directly to consumer. Retailers are interested in this model as it shifts their inventory responsibility upstream and frees up working capital. Manufacturers are intrigued with the prospects of drop shipping as a way to capture lost sales due to stockouts with retailers. They believe that their retailers might be providing lower-than-optimal service levels on certain high-value product categories that experience intense seasonality, leading to lost revenue opportunities for the manufacturer. Without having any true methods to investigate their retailer's inventory availability due to information asymmetry, they have a difficult time assessing these prospects.

In a partnership with a CPG manufacturer, we built a framework that can be used to assess the important aspects of a setting up a drop shipping model. We showed manufacturers and retailers how to assess the changes in working capital and distribution costs in the supply chain as well as how to bridge information gaps to gauge potential lost sales impacts.

Using data from the manufacturer, we compared the per-unit fulfillment cost of their current distribution model with their estimated costs under the drop shipping model. Based on the assumptions in the context between the manufacturer and one of their retailers, we found that the manufacturer would be able to set up these capabilities in an existing facility without exceeding its capacity. We also found that the drop shipping model would increase the total fulfillment cost for the manufacturer from $1.38 per unit to $3.64. The transfer of the distribution labor and inventory holding cost from the retailer to the manufacturer drives these cost shifts. However, it is important to note that the overall channel costs only increase by $0.12 per unit, as there are large savings by removing two stages of transportation and DC labor from the supply chain. We found that the model is sensitive to changes in cost assumptions, particularly parcel rates which make up the largest portion of the cost equation. Small changes in parcel rates could easily change which model operates at a lower cost. We also found that the retailer would be able to free up $3.28 million in working capital. In shifting models, the manufacturer would only need to take on $2.0 million in inventory. This may provide opportunity for contractual negotiations that are mutually beneficial. There is another concern from the perspective of the potential manufacturer- how the transition to drop shipping impacts their Profit & Loss (P&L) statement. Because the retailer will stop purchasing new inventory from the manufacturer as they burn down their on-hand stock, the manufacturer will record a period of zero sales. While timing the transition during a low sales period can help mitigate this effect, it will still be noticed in sales and profitability metrics.

However, we found a less convincing case for the manufacturer to gain revenue by capturing previously lost sales with the new drop shipping technique. To try and gauge the impact of potential lost sales, we used data from a Web Extraction System. This data, when combined with POS and outbound inventory data, can provide useful to gain more insight into retailer availability, which is often very difficult to access and analyze. While it may not show exactly what is on the shelves, it can still provide great visibility to potential stockouts. Using these techniques, we found that availability was actually very high for the SKU's considered. The retailer appeared to be carrying sufficient inventory (and in some cases, too much inventory) to handle the extremely volatile holiday demand. This finding may indicate some of the retailer's desire to have the manufacturer drop ship. This would allow the retailer to shed the high working capital cost required to fulfill these SKUs to customers.

We show that for domestic deliveries, the shift from multiple DC's to a single centralized facility increases the average delivery time by one day. In our context, this was not particularly significant, as the majority of product sales seemed to occur well before the actual holiday.

Given all of the above, we believe that, in the case of this manufacturer, a shift to this new model would only seem beneficial if the potential for lost sales were significantly higher and/or the retailer would compensate the manufacturer for the service. Another consideration that may drive the implementation of drop shipping is the competitive landscape. If other manufacturers were to agree to this, it may lead to them getting preferential treatment from retailers.

We have to take into consideration that these specific results we generated based on a limited SKU set produced by one manufacturer and offered by one retailer. While it does not undermine the value of the overall framework, the individual scenarios between retailers and manufacturers vary considerably and the model may need to be adjusted for each specific use.

One of the directions that was not considered in our framework is the value manufacturers could derive from obtaining detailed customer information from the drop-ship process. This includes among other things addresses, personal information and purchasing behavior. Presumably this information is very valuable and could enable the manufacturer to get closer to the customer through e.g. promotions, business models and products.

Further research could focus on the further development of Web Extraction Systems specifically for inventory level estimations under data constraints. There is also value in understanding the value that manufacturers can gain from closer interaction with their customers.

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