

Operating Strategies for a Segmented Supply Chain

by

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ABSTRACT

An operations strategy is a method or plan of action that corporations employ to reach their goals. A good strategy enables a company to operate efficiently and use its resources effectively. The purpose of this capstone project is to formulate optimal supply chain operating strategies for demand, sourcing, and distribution by replenishment stream for a fast-moving consumer goods company (FMCGC). A replenishment stream is how demand from an external customer flows into the sponsor company's supply chain. The sponsor company has identified four replenishment streams; base demand, promotions, new initiatives and incremental business activities. It seeks to confirm whether there is a benefit in differentiating the supply chain by the four identified streams of some hybrid. An exhaustive literature review and analysis of shipment data provided reveals that there is no one size fits all demand, sourcing, and distribution strategy in consideration of the different replenishment streams. In addition, through a variety of methods including segmentation, calculation of the coefficient of variation, time series analysis, and the generation of forecasts, I conclude that in certain instances there is a benefit to differentiating the supply chain by the 4 identified replenishment streams and in other cases it is advantageous to consolidate them by some hybrid.

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1. Introduction

The sponsor company is a multi-national manufacturer and distributor of a range of fast moving consumer goods. The company endeavors to drive efficiency and foster operational excellence through supply chain synchronization, which is their fundamental product supply strategy. Synchronization occurs when all entities in a supply chain operate as a single unit. In other words, it allows the company real time end to end supply chain visibility by organizing and managing the movement of information, products, and services through the network. This allows the supply chain to function in unison while simultaneously shaving costs and increasing customer satisfaction. Through supply chain synchronization, companies can match supply with actual customer demand. This means that the organization would source, produce, and ship the exact number of products needed to satisfy demand. Supply chain synchronization governs the choices and strategies made by the sponsor company of this project.

The sponsor company fulfills orders based on the initial demand signal from its customers which is broken down into 4 unique replenishment streams. A replenishment stream denotes how demand from an external customer flows into the sponsor company's supply chain. The four streams, expounded upon in section 1.1, are base demand, promotions, incremental business activity, and new initiatives. The objective of this paper is twofold:

- 1) To identify whether there is a benefit to differentiating the supply chain by the four identified replenishment streams or some hybrid.
- 2) To identify the optimal supply chain operating strategies for demand, sourcing, and distribution that minimize cost, increase cash, and maximize service and sales for the sponsor company's customers.

My initial hypothesis was that there is a benefit to differentiating the supply chain by a hybrid of streams. For demand, I theorized that it would be advantageous to pool the streams together in order to reduce variability. I postulated that aggregating demand would lead to an increase in forecast accuracy as it would decrease the uncertainty that results from high variability. A more accurate forecast would result in the reduction of required safety stock and therefore average inventory. In order to validate my hypothesis, I calculated the coefficient of variation for each of the streams and a hybrid of the streams using provided shipment data in order to measure demand variability and determine the optimal combination of streams. I then conducted a time series analysis for each of the streams and identified optimal combination of streams in order to

detect underlying patterns and understand demand's variations and oscillations over time. Finally, I calculated the accuracy of the forecasts using the mean absolute percent error (MAPE) for each stream and a combination of the streams. I also explored instances in which it would be disadvantageous to pool the streams together.

My initial hypothesis for the distribution strategy is that the company would benefit from shipping products that require a fast turnaround via direct shipment from manufacturer to end customer. In order to test my theory, I mapped out the company's supply network through interviews with key employees. This provided visualization of the product flow and clarity of the distribution strategies being used by the sponsor company. Using the provided shipment data, I did a stratification by stock keeping units (SKUs) and by customer in order to identify the customers and SKUs responsible for a lion's share of the shipments. I also segmented the replenishment streams by customer to see if shipment volume by stream was being driven by orders from a particular customer. Furthermore, I calculated the case fill rate for the top customers by replenishment stream as it is a key measurement of customer service for the sponsor company. In order to validate my hypothesis, I analyzed the case fill rate by replenishment stream against the segmentation of the streams by customer and shipment volume.

For the sourcing strategy, I posited that the sponsor company can source materials for the identified optimal hybrid of streams with low variability from distant low-cost suppliers. I theorized that streams requiring a fast turnaround can be sourced from local suppliers. By consolidating the demand streams, the sponsor company will enjoy greater purchasing leverage through economies of scale. SKU segmentation, coefficient of variation calculations and interviews with key employees in the sponsor company were used in the validation of this hypothesis.

The hypotheses and methodologies contained herein were formulated through an exhaustive literature search, analysis of provided data, interviews with pertinent employees at the sponsor company, and with academic supply chain and strategy experts. The rest of this section expounds on the research questions that this paper will address. The following section **2** explores the literature reviewed. Section **3** describes the data received from the sponsor company and highlights the methods used to manipulate and analyze it in order to formulate strategies in consideration of the four replenishment streams. Section **4** discusses and analyzes the results from the calculations based on the methodologies outlined in the previous section. It synthesizes the key

findings and provides answers to the aforementioned research questions. Section 5, the conclusion, provides a high-level synthesis of the key findings, discusses limitations or factors that affected the findings, and offers suggestions for next steps.

1.1 Problem Description

For each of these replenishment streams, the sponsor company would like to identify the optimal supply chain operating strategies to minimize cost, increase cash flow, and maximize service and sales with its customers who are primarily retailers and distributors. The company wishes to confirm if there is a benefit in differentiating the supply chain by the four replenishment streams identified below or some hybrid.

1. **Base Demand** – Everyday movement of product, characterized by a very stable demand signal. A lion's share of product movement is characterized by this profile.
2. **New Initiatives** – This replenishment stream is driven primarily by the customer launch plan. Under this stream, new stock keeping units (SKUs) are brought to market for the first time. The FMCG company defines a new SKU as either an entirely new product or as an iteration of an existing product but with improved features. According to the sponsor company, new initiatives are typically introduced from April to May and from October to December.
3. **Merchandising & Promotion** – Planned promotional activities, such as ads in retail stores, drive demand spikes in both shipments and sales. Promotions are planned and the sponsor company coordinates with customers to gather demand planning information four to six weeks in advance.
4. **Incremental Business Activities** – Unplanned demand spikes often occur with very little notice. These spikes are caused by broader market activities such as a competitor promotion. There is usually no early warning signal for this replenishment stream. The sponsor company is typically able to respond to the customer quickly (within two to four weeks).

It is important to note that the streams are not a property of the SKU. As depicted in figure 1, over the span of a year, a SKU can be phased in as a new initiative, transitioned into base demand and have some promotional activity with heavy shipments during its life cycle. Additionally, a SKU can be a few different streams within a period depending on the demand signal from different customers.

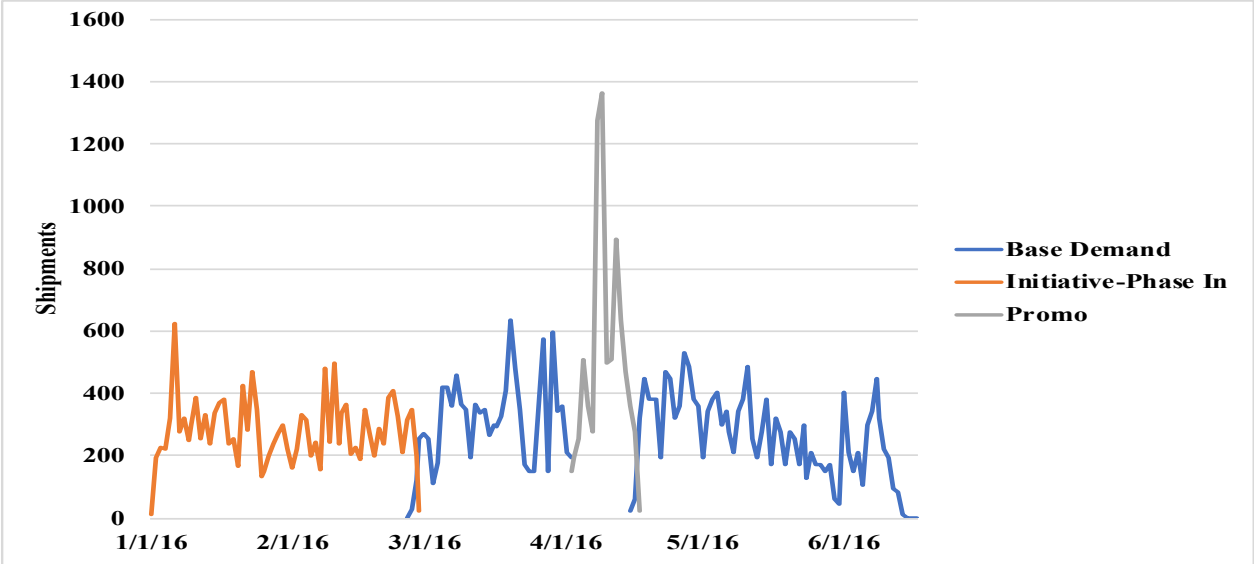


Figure 1: Example of a SKU's behavior over time

2. Literature Review

Based on thorough literature review, I sought to answer a three-prong question: (1) are there case studies or other companies that employ segmentation similar to the sponsor company? (2) If so, what choices or operating strategies do they make based on their segmentation? and (3) what are the components of a successful demand, distribution, and sourcing strategy? Answering these questions is essential to determining whether tracking and setting operation strategies by discrete or a hybrid of the identified replenishment streams makes sense. The literature search helped to identify the tools and methodologies necessary in formulating demand, sourcing, and distribution strategies in regards to the streams as it relates to the sponsor company.

2.1 Case Studies

In conducting the literature review, I uncovered three separate studies of companies that segment and think about demand in a similar way to the sponsor company.

1. Colgate Palmolive: research was conducted by the organization in conjunction with a small consulting company known as Chainalytics
2. An unnamed fast-moving consumer goods company in Europe: research was conducted by professors at Cranfield University
3. A biopharmaceutical company: research was conducted by BCG consulting, a leading global management consulting firm.

The main takeaway from all three studies was that different operating strategies need to be taken for different streams as a “one size does not fit all” approach in shaping operating strategies fails to consider the nuances inherent in each stream. The following section **2.2** will explore the significant points from the case studies. Section **2.3** will delve into the key components of a successful demand, distribution and sourcing strategy according to existing literature.

2.2 Segmentation and Strategy

Supply chain segmentation describes an approach for developing differentiated supply chain strategies through the creation of distinct segments (Protopappa-Sieke & Thonemann, 2017). A segment is based on a specific set of characteristics and criteria corresponding to product or customer needs. For each of the segments, a distinct supply chain strategy that corresponds with

the products or customers' requirements is formulated. (Childerhouse, Aitken, & Towill, 2002; Godsell, Harrison, Emberson, & Storey, 2006; Lovell, Saw, & Stimson, 2005).

According to an article published by BCG Consulting titled "Segmentation in the Consumer Supply Chain: One Size Does Not Fit All," by Peter Dawe, et al. (2015), disregarding segmentation "exacerbates supply chain pressures and leads to a decline in service levels, unnecessary costs, waste, and subpar customer outcomes." In the article, the authors highlight a U.S based biopharmaceutical company that sectioned demand based on volume and variability. For its high-volume, low-variability segment, represented by base demand for the sponsor company, the biopharmaceutical company aimed for stable inventory and a make to stock manufacturing approach. For its low-volume, high-variability segment, represented by the promotional activity stream for the sponsor company, the biopharmaceutical company pursued a make-to-order strategy to reduce its inventory levels. According to the article, "as a result, top products enjoyed shortened lead times and the company was able to allocate resources more sensibly, trim inventory and waste, and reduce obsolescence."

Segmentation Matrix
Volatility (CV%) vs. Volume

Volatility of Demand	HIGH	<p>LOW VOLUME HIGH VOLATILITY</p> <p><i>Hard to Predict Low Impact Items</i></p>	<p>HIGH VOLUME HIGH VOLATILITY</p> <p><i>Hard to Predict High Impact Items</i></p>
	LOW	<p>LOW VOLUME LOW VOLATILITY</p> <p><i>Easy to Stat Forecast Low Impact Items</i></p>	<p>HIGH VOLUME LOW VOLATILITY</p> <p><i>Easy to Plan/Forecast High Impact Items</i></p>
		LOW	HIGH

Figure 2: Colgate and Palmolive Oil Segmentation Matrix

In the APICS 2013 conference and expo, Jeff Metersky of Chainalytics, a supply chain consulting firm, and Jim Davis of The Colgate-Palmolive Company presented on "Segmentation in Demand Planning for Enhanced Forecast Accuracy." Their presentation focused on a segmentation strategy for Colgate-Palmolive, a consumer-packaged goods company. Similar to Dawe et al. (2015) at BCG, Colgate-Palmolive considers volume and variability or volatility in its segmentation. It measures volatility by

calculating the coefficient of variation or the ratio of standard deviation over mean. Unlike By combining demand volatility and volume in a 2 by 2 matrix, Chainalytics derives the four corresponding strategies:

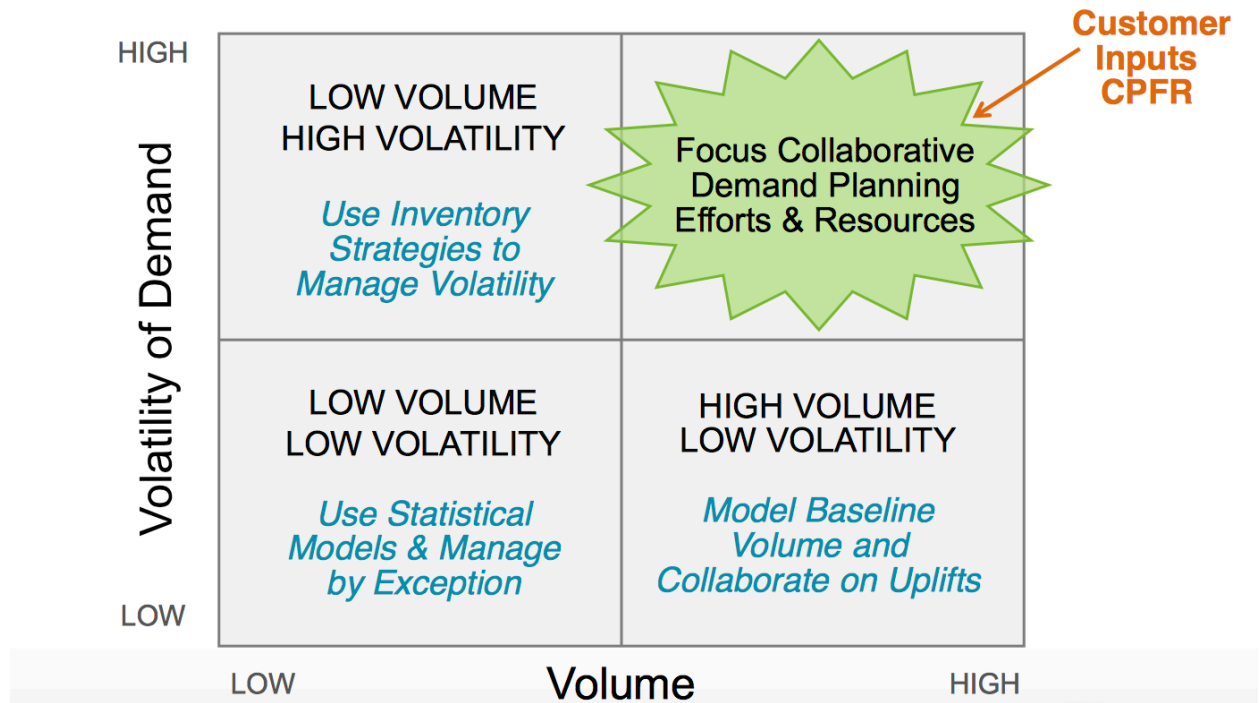


Figure 3: Chainalytics Strategies

As mentioned earlier, the four replenishment streams identified by the sponsor company are not a characteristic of the stock keeping unit (SKU). Therefore, over the span of a year a SKU can be phased in as a new initiative, transitioned into base demand and have some promotional activity with heavy shipments during its life cycle. Colgate-Palmolive does not seem to have this type of dynamic segmentation and though not explicitly stated, it is implied that Colgate-Palmolive segments by unique SKU. This means that a SKU occupies only one segment of the matrix in figure 2.

In the research article “Enabling Supply Chain Segmentation through Demand Profiling,” Godsell et al. (2010) conduct a field-based case study to explore the optimal way a fast-moving consumer goods company in the United Kingdom could segment its supply chain and leverage the learnings across the company. This task was undertaken in an effort to help the corporation improve its service levels while reducing costs. According to the research article, the team received 24 months of data at a SKU level of granularity which was sorted and structured into a monthly demand series at a stock level for each SKU. From research and analysis of the data, Godsell et al. found that volume and variability are the 2 most relevant measures for demand segmentation at a product level. Demand variability for the study was defined by the formula for coefficient of variation; standard deviation over mean. The analysis found that there was a high level of volatility

for a large number of SKUs giving way to “demand hostility.” The authors of the paper define demand hostility as a situation where “products require high inventory (in relation to sales), suffer from high lost sales or need frequent expedited shipping.” This consequently negatively influences a corporation’s service levels and supply chain costs. For the sponsor company of this project, demand hostility would result from the incremental business activity (IBA’s) stream. IBAs have a high level of volatility as they are characterized by unplanned demand spikes that occur with very little notice. These activities are caused by broader market activities such as a competitor promotion. There is usually no early warning signal for this replenishment stream but the sponsor company is typically able to respond to the customer quickly, within two to four weeks.

Although Godsell et al. conclude that their proposed methodology is “robust and capable of extension to other contexts,” similar to Dawe et al. from BCG, they caution that a supply chain strategy needs to be “crafted and not copied” with cases and data appropriately fitted to frameworks as applicable.

2.3 Demand Strategy

Much of the focus of the literature reviewed in regards to a demand strategy is centered around variability. The consensus in the literature is that demand variability is a key factor in strategy formulation. Demand variability refers to the changes in customer demand from period to period. Christopher and Towill (2009) developed a binary gradation of demand and distill it to either stable or volatile demand. They recommend that a lean strategy with an efficient low-cost supply chain be employed where demand is stable and an agile strategy that requires flexibility where demand is volatile. According to Godsell et al. (2009) “stable demand is the easiest to plan for, and the cheapest to produce as the requirements for buffers (e.g. spare capacity or inventory) are minimized. It therefore benefits both the supply chain and the customer, as supply is reliable and low cost.” Adversely, an agile supply chain is characterized by flexibility as it aims to maintain a competitive advantage in a dynamic landscape by providing products tailored to unique customer specifications to the market quickly.

In order to reduce variability in demand, Oeser (2015) recommends consolidating individual variabilities by pooling demand which causes higher than average demands to balance out the lower ones. This concept is also known as risk pooling and can be applied by aggregating demand across products, time, location, and/or customers. Oeser (2015) argues that by reducing

uncertainty, a corporation can reduce inventory without negatively affecting customer service level or product availability. Cattani and Schmidt (2005) contend that by pooling customer demand, resources used to fill those demands are also pooled thereby leading to improvements through streamlined operations. In addition, consolidating demand and therefore reducing variability leads to a decrease in safety stock thus reducing average inventory needed to achieve a target service level (Simchi-Levi and Kaminsky, 2003). The benefit from pooling is likely to be large when the underlying forecast error is high (Chopra and Meindl, 2007). Pooling demand and therefore aggregating forecasts leads to more accurate forecasts due to statistical balancing effects and economies of scale (Oeser, 2015).

Another benefit derived from risk pooling is postponement or delaying the point of product differentiation especially where customers demand variety. Per Simchi-Levi and Kaminsky (2003) in postponement, “generic products are shipped as far as possible down the supply chain before variety is added. This could mean that the product is received in the distribution center, and there it is modified or customized according to customer demand.” The concept of pooling is evident here because by shipping a generic product to the distribution center, customer demand has been pooled across all goods.

In each instance, the benefits of pooling must be evaluated against any potential disadvantages to ascertain the best operating strategy for an organization. Risk pooling is more effective in circumstances where demand is negatively correlated due to uncertainty. Negative correlation means that demand is stable and the coefficient of correlation is low. According to Simchi-Levi and Kaminsky (2003), “we say that demand from two markets is positively correlated if it is very likely that whenever demand from one market is greater than average, demand from the other market is also greater than average.”

2.4 Distribution strategy

Distribution is the set of activities taken to move a product from the supplier to a customer in the supply chain network (Chopra and Meindl, 2007). An effective distribution strategy streamlines a company’s operations and ensures customer satisfaction through high service levels. An appropriate distribution strategy is a crucial element in the profitability of a firm because it affects both the supply chain cost and the customer experience directly (Chopra and Meindl, 2007). According to Simchi- Levi and Kaminsky (2003), there are 3 distinct distribution strategies: direct

shipment, warehousing, cross docking. Chopra and Meindl (2007) identify transshipment as another viable distribution strategy. The four strategies are expanded upon below:

- **Direct shipment:** In this strategy, products are shipped directly from the manufacturer to the retail stores, bypassing distribution centers. This strategy also leads to an increase in the cost of transporting the goods for the manufacturer and distributor as they now must deploy smaller trucks or less than truckload shipments to more locations. This strategy is optimal if (1) the company can send shipments in a fully loaded truck or (2) lead time is critical.
- **Warehousing:** In this strategy, products are kept in stock at a distribution center or warehouse and are shipped to the customer when ordered.
- **Cross Docking:** Unlike direct shipment, in this strategy products are shipped from the manufacturer to retail stores through a distribution center or warehouse. Products typically do not stay long at the distribution center or warehouse therefore curbing inventory costs and reducing lead time by decreasing the amount of time goods are stored at the warehouse.
- **Transshipment:** Products are shipped between different facilities at the same level in the supply network in order to meet urgent needs or consolidate shipments for the end customer.

In the thesis, “Framework for Selection of Distributions Strategies,” Chunlin Li (2008) warns that “there is no single magic distribution strategy to solve every company’s problems. When selecting which strategies are fit for the company, often we need to utilize a combination of strategies in different sections based on the company’s situations. It does not matter which strategy we select, we need to consider the company’s distribution system as a whole to optimize the overall performance based on the customer’s needs and costs to meet those needs.”

2.5 Sourcing strategy

Sourcing refers to the set of activities required to purchase goods and services. As per Parniangtong (2016), “sourcing strategically is the process of developing channels of supply at the lowest total cost, not just the lowest purchase price. It expands upon traditional purchasing

activities to embrace all activities within the procurement cycle, from specification to receipt and payment of goods and services.” An effective sourcing strategy can increase profits for an organization and give it a competitive advantage against its competitors. Chopra and Meindl (2007) identify the key components in the formulation of a sourcing strategy for an organization as:

- The decision whether to perform a task in-house or farm it out to a third party. The authors assert that “it is best to outsource if the growth in total supply chain profit is significant with little additional risk.” Simchi- Levi and Kaminsky (2003) identify some of the motivations for outsourcing as (1) the economies of scale that can be realized by a third party that is able to aggregate orders from a large number of companies (2) reducing capital investment (3) allowing the organization to focus on its core competencies, and (4) transferring demand uncertainty to a third party as they can take advantage of the risk pooling by consolidating orders from different customers. All of these motivations are in an effort to reduce total supply chain costs.
- The decision whether to procure materials from a single source or multiple sources. This includes identifying what goods and quantity of the goods to procure from expensive local suppliers with a short lead time and what goods and quantities to procure from cheaper but distant suppliers with a long lead time. This set of activities revolves around supplier evaluation and selection.
- Last but not least, the procurement structure and design. Procurement by definition is the purchasing of goods and services. The goal is to procure items at services at the best possible price in consideration of the quality, quantity and lead time (Weele, 2010).

Although sourcing strategies largely focus on reducing costs, according to Parniangtong(2016), “its foundation is building longer term, win-win relationships with key suppliers to give buyers a competitive advantage.” The author contends that the relationship between the buyer and supplier is important to a successful sourcing strategy as both parties need to collaborate and “share information to identify opportunities that will significantly increase savings over time.”

3. Methodology

This methodology section delineates the measures taken to answer the two research questions that form the foundation for this project:

- 1) Is there a benefit to differentiating the supply chain by replenishment stream or a hybrid of the streams?
- 2) What are the optimal supply chain operating strategies for demand, sourcing, and distribution that minimize cost, increase cash, and maximize service and sales for the sponsor company's customers?

My initial hypothesis, supported by an exhaustive literature search, is that there is an operational and financial benefit to differentiating the supply chain by a hybrid of streams. Like Holfmann and Stolzle, I theorized that different strategies need to be applied in order to satisfy customer needs and minimize costs for the company.

Section **3.1** presents an overview of the methodology. Section **3.2** describes the data provided by the sponsor company. Section **3.3** chronicles how the data was cleansed and structured for the purposes of this analysis and section **3.4** highlights the methods used to manipulate and analyze the data in order to formulate strategies for demand, distribution, and sourcing in consideration of the four replenishment streams.

3.1 Methodology Overview

The first phase of this analysis was to examine the theoretical frameworks presented in the literature review through the lens of the CPG company. The frameworks were validated through weekly discussions with pertinent company employees and through an in-depth examination of provided data which was structured and manipulated for the purposes of this analysis. Table 1 provides a high-level illustration of the processes and key dimensions discussed herein.

Table 1: Methodology

Stage	Methods	Key Dimension
Scope Project & Build Hypothesis	Literature Review	<ul style="list-style-type: none"> ❖ Comprehensive search of previous research on the on the viability and current use of demand stream identification and management ❖ Evaluation of how other companies set operation strategies with respect to replenishment streams
	Interviews	<ul style="list-style-type: none"> ❖ Weekly meeting with key staff at the sponsor company ❖ Interviews with academic supply chain and strategy experts ❖ Onsite visit of sponsor company facilities
Data Gathering	Data Collection from Sponsor Company	<ul style="list-style-type: none"> ❖ Shipment data from Jan,2016- Jul, 2017 at SKU level of granularity ❖ Geolocation mapping of companies mixing centers ❖ Total delivery cost data by SKU
Data Analysis	Data Structuring	<ul style="list-style-type: none"> ❖ Truncated 835 SKUs to 143 Pertinent SKUs ❖ Combined shipment data with total delivery cost data using a common identifying SKU
	Data Analysis	<ul style="list-style-type: none"> ❖ Time series analysis ❖ Product and customer segmentation ❖ Coefficient of variation calculations per SKU/replenishment stream/product type/date

3.2 Data

The CPG company provided data for 835 SKUs January 2016 to July 2017 for the North American market. The data is broken up at a SKU level of granularity by customer, brand name, shipment date, ship from location, amount ordered, amount shipped, and replenishment stream. Separate smaller files were also provided that include information for geolocation mapping of the company’s mixing centers and the company’s two main manufacturing locations, corresponding to approximately 96% of total shipments. The total delivery cost data was provided in a separate file.

3.3 Data Structuring

The initial dataset contained approximately 100,000 rows of shipment data over the span of 19 months for 835 distinct SKUs. The data covered 7 brands of a product family which were filtered to the 3 brands pertaining to the project scope. This pruned the number of distinct SKUs down to 143. The total delivery cost data provided under a separate file was combined with the

shipment data set using a common identifying SKU number for ease of analysis. The total delivery cost file had missing cost data information and therefore was not used.

3.3.1 Data Analysis

3.3.1.1 Segmentation

Segmentation is a prerequisite for effective strategy formulation. By understanding the profiles of customers and products, a company can appropriately tailor its strategies to each of them and thus increase its overall profitability. Therefore, a Pareto analysis by SKU and by customer was applied to classify the vital few from the trivial many. This type of evaluation aids in segmenting items according to their relative importance and helps to identify the SKUs or customers that have the greatest impact. To identify the top SKUs responsible for a majority of the volume, shipment data was aggregated for each SKU and sorted in descending order. The same analysis was done to distinguish the top customers. The result was a distribution in line with the Pareto principle where a few of the customers or products account for approximately 80% of the total demand or volume.

3.3.2 Demand Strategy

The sponsor company identifies its demand operating strategy elements as the choices it makes in managing variability and volume growth, opportunities to leverage scale, and market priorities. Based on this in conjunction with a literature review, I hypothesized that it would be beneficial to pool the streams together in order to reduce variability. Aggregating demand and therefore decreasing the uncertainty that results from high variability leads to increased forecast accuracy which is a measure of how close the actual demand is to the forecasted quantity. More accurate forecasts result in a reduction of required safety stock as demand is more stable and consequently leads to lower average inventory (Oeser, 2015). In order to validate my hypothesis, the methods below were executed in chronological order and explain how demand was aggregated and forecasts were generated and measured for accuracy.

3.3.2.1 Coefficient of Variation

The coefficient of variation, also known as relative standard deviation, is used to measure demand variability or uncertainty. It is calculated by dividing the standard deviation by the mean. A high coefficient of variation indicates an increase in variability. Therefore, the higher the

coefficient of variation, the greater the impact derived from risk pooling and aggregation of demand. Risk pooling is used to achieve statistical economies of scale through demand aggregation and is beneficial in managing operational uncertainties. For the purposes of this project, a coefficient of variation was calculated for each replenishment stream and also a hybrid of the streams. This was conducted in order to ascertain whether its beneficial to treat the streams differently or if a hybrid of the streams would be optimal. The analysis was also disaggregated by SKU, customer, and time in order to garner further insights.

3.3.2.2 Time Series Analysis and Forecasting

A time series analysis was conducted based on the shipment dataset in order to identify underlying patterns and understand demand's variations and oscillations over time. The analysis was done for each replenishment stream and for a hybrid of the replenishment streams by plotting the shipment volume over a series of time. The purpose of the analysis was to identify and isolate the following patterns in order to appropriately select an appropriate forecasting method to be used in the formation of the demand strategy.

- **Trend-** The change (linear, non-linear, exponential etc.) in data over a series of time.
- **Level-** Oscillation of data around the average.
- **Seasonal-** Repeating oscillations depending on the week, month, season or year. At least two years' worth of data is required in order to ascertain whether there is seasonality.
- **Cyclical-** Irregular oscillations over years or decades.
- **Random-** The unforecastable variation in demand.

The time series plots as delineated in the section above revealed oscillations of data around the average, or level, for the promotional and incremental business activities streams. The base demand stream exhibited an increasing trend over time with oscillations around the mean (level and trend). It is important to note that since the data provided only spans 19 months, seasonality could not be observed as at least 2 years of data is required to determine whether there are any seasonal variations.

Since the promotional and incremental activities stream exhibited only level with no observable trend, the simple exponential smoothing method was used to create their forecasts. Exponential smoothing is a weighted average of all past data points with newer data points receiving more weight than older observations (Simchi-Levi and Kaminsky, 2003). The following is the formula for simple exponential smoothing:

$$\hat{x}_{t,t+1} = \alpha * x_t + (1 - \alpha) * \hat{x}_{t-1,t} \quad (\text{Equation 1})$$

Where

t = time

$\hat{x}_{t,t+1}$ = forecast sitting in time t for time $t + 1$

α = a smoothing constant for level between 0 and 1

x_t = Actual demand

$\hat{x}_{t-1,t}$ = Forecast for current period made in last period

Unlike promotional and incremental business activities, the base demand stream exhibited oscillations around the mean (level) with an observable increasing trend. Therefore, the Holt method was used to create the forecast for base demand. The Holt's method is simple exponential smoothing expanded to include trend (Simchi-Levi and Kaminsky, 2003). It is calculated as follows:

$$\begin{aligned} \hat{x}_{t,t+\tau} &= \hat{a}_t + \tau * \hat{b}_t \\ \hat{a}_t &= \alpha * x_t + (1 - \alpha) * \hat{x}_{t-1,t} \\ \hat{b}_t &= \beta * (\hat{a}_t - \hat{a}_{t-1}) + (1 - \beta) \hat{b}_{t-1} \end{aligned} \quad (\text{Equation 2})$$

Where

$\hat{x}_{t,t+\tau}$ = Forecast sitting in time t for $t + \tau$

α = a smoothing constant for level between 0 and 1

β = a smoothing constant for trend between 0 and 1

τ = Periods

\hat{a}_t = Estimate of level at end of time period t

\hat{b}_t = Estimate of trend at the trend of time period t

$t - 1$ = Previous period

Based on results from coefficient of variation calculations as described in the preceding section, the forecast for the optimal combination of streams was also calculated based on the observed pattern from the time series analysis.

It is important to note that the purpose of creating the forecasts by stream and a hybrid of streams is to test the hypothesis that pooling the streams and thereby aggregating the demand results in more accurate forecasts. The accuracy of the forecasts was measured by a calculation of

the mean absolute percent error (MAPE) which is the average absolute error as a percentage of demand. A low MAPE indicates a more accurate forecast. It is calculated as follows:

$$\text{MAPE} = \frac{\sum_{t=1}^n \frac{|e_t|}{A_t}}{n} \quad (\text{Equation 3})$$

Where

e_t = error for observation t calculated as Actual – Forecast

n= Number of observations

A_t = actual value for observation t

F_t = Forecasted value for observation t

3.3.3 Distribution Strategy

Distribution is the set of activities associated with transporting goods from the premises of a manufacturer or distributor to intermediary points and end users. An effective distribution strategy ensures customer satisfaction through high service levels and streamlines a company's operations. The key elements that influence a distribution strategy are customer demand and location, service level, and costs including transportation and inventory costs (Simchi-Levi and Kaminsky, 2003). As delineated in the literature review, there are four distinct distribution strategies; direct shipment, transshipment, warehousing, and cross docking.

The sponsor company's strategic choice in regards to distribution is centered around ensuring a high level of customer service. A key metric of customer service for the company is the case fill rate which is a measurement of the amount shipped against the amount ordered. The sponsor company's aims for a case fill rate of 98% or greater for its top customers.

For this project, I hypothesized that the sponsor company would benefit from shipping products that require a fast turnaround via direct shipment from manufacturer to end customer. I theorized that if the products being analyzed herein were not enough for a full truckload shipment then it would be beneficial to include them with other products being shipped directly to the end customer. In order to formulate a proper distribution strategy for the sponsor company, I mapped out the company's supply network through interviews with key employees. This provided visualization of the product flow and also clarity in regards to which of the four distribution strategies delineated above were being employed. I further segmented the replenishment streams by customer to see if shipment volume by stream was being driven by orders from a particular

customer. I also calculated the case fill rate for the top customers by replenishment stream as it is a key measurement of customer service for the sponsor company.

The below expounds on the network mapping, segmentation, and calculation of case fill rate that was done in order to arrive at an appropriate distribution strategy in consideration of the four replenishment streams.

3.3.3.1 Distribution Network Mapping

I mapped out the company's supply network with the help of key staff at the sponsor company in order to properly understand the sponsor company's distribution network. This map, as depicted in the results section 4, illustrates and expounds on the functions of the sponsor company's 6 mixing centers and 2 manufacturing plants.

3.3.3.2 Case Fill Rate

Case fill rate (CFR) is a measure of the customer service level and satisfaction of the customers. It is a ratio between 0 and 1, calculated by dividing the amount shipped by the amount ordered. A CFR that is less than 1 indicates that the sponsor company shipped less product than the customer ordered while a CFR greater than one implies the adverse. For its top customers, the sponsor company aims for a CFR level greater than 98%. I calculated CFR at an aggregated level by customer and also at a disaggregated level by stream and customer. This was in an effort to evaluate how the CFR varies across streams.

3.3.3.3 Segmentation

In addition to the initial segmentation by SKU and customer that was performed as delineated at the beginning of this section 3.4, I calculated the cumulative weights of shipment by stream and segmented the SKUs by stream and customer. Segmentation at this level of granularity was executed in order to ascertain if shipment volume by stream was being driven by orders from a particular customer. I theorized that if a customer was responsible for driving shipments for a stream that requires fast turnaround such as incremental business activities, then direct shipment from the manufacturing plant to retailer would be warranted.

3.3.4 Sourcing Strategy

Sourcing is the set of activities required to procure goods and services. Sourcing decisions are critical as they influence the level of efficiency and responsiveness that the supply chain can achieve (Chopra and Meindl, 2007). As highlighted in the literature review, the key components of choices in relation to a sourcing strategy are (1) whether to perform a task in-house or outsource to a third party (2) whether to procure materials from a single source or multiple sources and (3) the procurement structure and design (Chopra and Meindl, 2007). A strategic sourcing decision also necessitates an assessment of what a corporation procures, from whom, at what price and quantity. For this project, only data related to the shipment of goods to the retailers is available. Therefore, through an assessment of the shipment data, I hypothesized that by pooling demand and thereby decreasing variability would provide the sponsor company with an opportunity to source its materials from a distant low-cost supplier. I theorized that streams requiring a fast turnaround such as incremental business activities can be sourced from local suppliers. By consolidating the demand streams, the sponsor company will enjoy greater purchasing leverage through economies of scale. The coefficient of variation and SKU segmentation, as described in the methodology section, as well as interviews with key employees in the sponsor company were used in the validation of this hypothesis.

4. Results and Discussion

This section represents the results from the calculations conducted based on the methodology outlined in the previous chapter. It presents an analysis of the findings which are used to formulate demand, sourcing, and distribution strategies in consideration of the four replenishment streams. As previously stated, the main questions that this capstone project seeks to answer are;

- 1) Is there a benefit to differentiating the supply chain by replenishment stream or a hybrid of the streams?
- 2) What are the optimal supply chain operating strategies for demand, sourcing, and distribution that minimize cost, increase cash, and maximize service and sales for the sponsor company's customers?

4.1 Demand Strategy

4.1.1.1 Pooling

An analysis of the percent shipment volume by stream was performed in order to get a picture of product movement by demand signal and to get a better understanding of the profile of each stream. It revealed that 73% of total shipments stemmed from the base demand stream, followed by the promotional stream at 17% with initiatives and incremental business activities (IBA) accounting for a total of 10% of shipments.

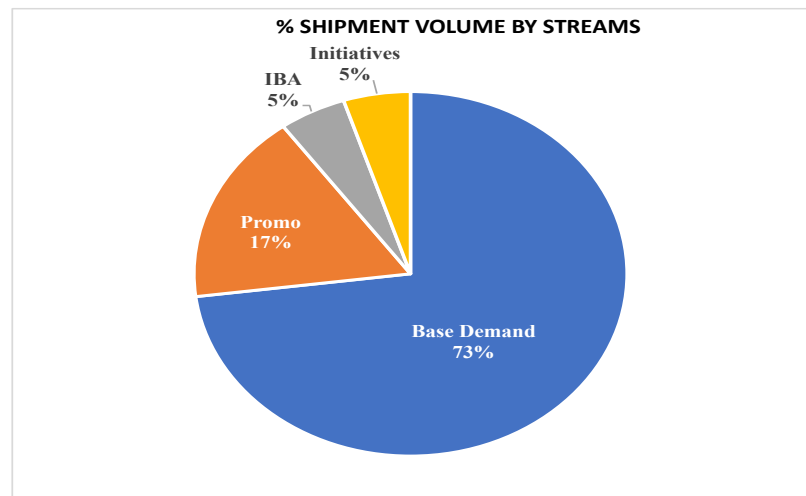


Figure 4: % Shipment Volume by Stream

In order to ascertain whether pooling the streams and treating them the same makes sense, I calculated the coefficient of variation for each stream and for a hybrid of streams. As discussed in the methodology section, the coefficient of variation is used to measure demand variability. A higher coefficient of variation is indicative of a high level of uncertainty. Therefore, the higher the coefficient of variation, the greater the impact derived from aggregation of demand. The calculations for the coefficient of variation were disaggregated by stream and time. New initiatives were not considered with the rest of the replenishment streams as their production is dependent on

customer launch plans for new SKUs. Thus, the new initiative stream only exists during product launch.

The results as displayed on figure 5 brought to question whether there is a benefit in treating the demand streams differently (especially since the streams are not a characteristic of the SKU). As expected, out of the standalone streams, base demand had the lowest coefficient of variation at 32.3%. This is followed by the promotional stream at 74% and IBA at 168%.

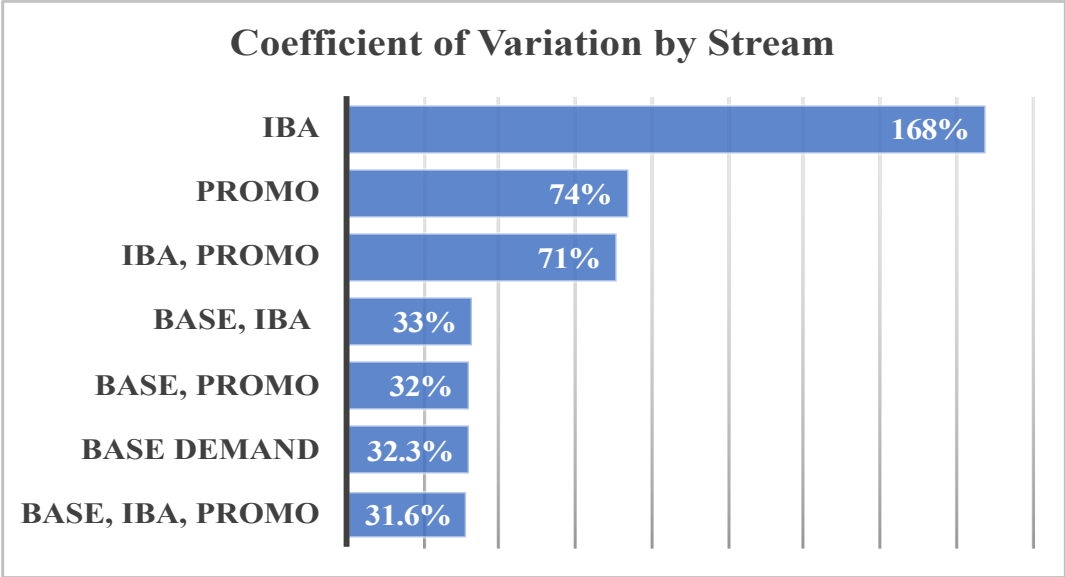


Figure 5: Coefficient of Variation by Stream

The streams were also pooled together in different combinations. The aggregated shipments of base demand, promotional, and IBA streams resulted in the lowest coefficient of variation at 31.6% with base demand as the driving force for the low figure as it accounts for 73% of all shipments. Based on this analysis, the optimal hybrid of streams is base demand, promotional, and IBA.

It is important to note that the sponsor company stands to reap the most benefit in pooling if the streams have different variations and uncertainty in demand. The more positively correlated the streams are, the less it makes sense to pool. According to Oeser (2015) “the benefit of pooling generally increases with decreasing correlation of pooled demands and concentration of uncertainty as well as increasing variability. Pooling usually shows increasing returns, but decreasing marginal returns, so that the main benefit can be gained by partly application and complete application might not be necessary or cost efficient.” Therefore, contained herein are demand strategies for when the streams are pooled and when they are not pooled.

4.1.1.2 Time Series Analysis and Forecasting

Shipments were plotted by stream in order to identify underlying patterns and understand variations and oscillations in shipments over time. Figure 6 represents shipments aggregated by week. It reveals that base demand has an increasing trend with oscillations around the mean. It has weekly movement of product with the highest shipment in December at week 52 and the lowest around week 13 which is the beginning of April. The promotional stream has oscillations around

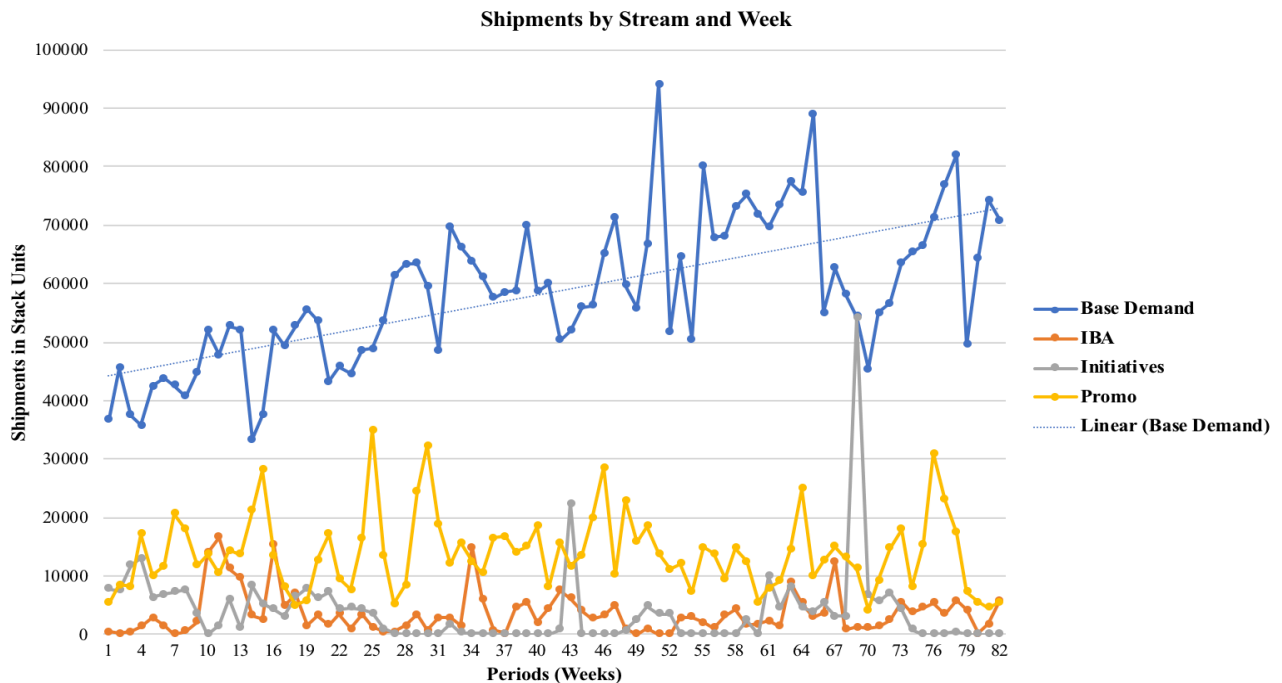


Figure 6: Shipments by Stream and Week

the mean but exhibits no trend. It has weekly movement of product though at a lower volume than the base demand profile. The promotional stream is characterized by spikes in shipment at various periods throughout the year. Interviews with key staff members revealed that spikes are driven by ads and promotional offerings by the retailers. The initiative stream had periods where it had little to no activity followed by drastic spikes in shipments. These spikes occur around April and October. According to the sponsor company, the spikes represent periods where new SKUs, an entirely new product, or an iteration of an existing product is phased into the market. The incremental business activities (IBA) stream has less periods of no activity than the new initiatives profile but more spikes in shipments. The spikes in shipments for IBA are less drastic than that of the new initiatives stream. Both profiles have oscillations around the mean but do not exhibit a trend. Since the shipment data provided only spans for 19 months, seasonality could not be

observed as at least 2 years of data is required to determine whether there are any seasonal variations. These observations were used to create forecasts for each stream in order to validate my hypothesis that consolidating the streams would result in an increase forecast accuracy and thus a lower forecast error.

As discussed in the methodology section, Holt’s method was used to create forecasted values for the base demand stream since it exhibited both level and trend. The plot below displays the forecasted versus actual values, each period represents a week.

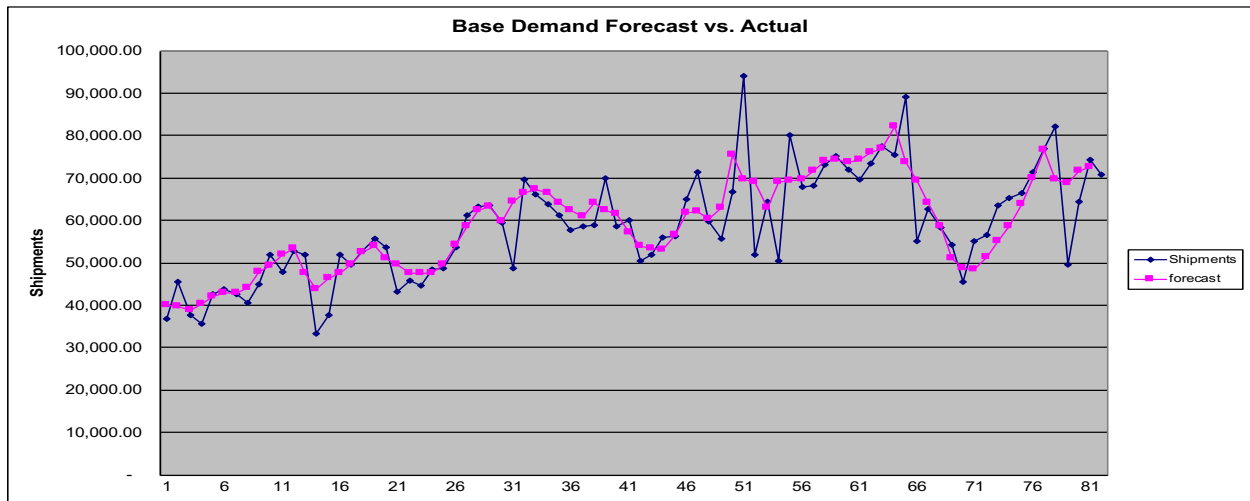


Figure 7: Base Demand Forecast Vs. Actual

The forecast accuracy was measured using mean absolute percent error (MAPE). As discussed in the methodology section, MAPE is the average absolute error as a percentage of demand. A low MAPE is indicative of an accurate forecast. Please note that the modeling concept of MAPE contained herein is theoretical.

A low coefficient of variation is indicative of a low forecast error (Mant, 2001). Base demand had the lowest coefficient of variation at 32.3% and as expected, its MAPE is relatively low at 9%. Base demand has a stable demand pattern and is characterized by the sponsor company as the replenishment of stock that has been sold. Therefore, if the supply chain was to be differentiated by the four streams and each stream was treated individually, then it would be beneficial for the sponsor company to adopt a lean strategy for the base demand stream. A lean strategy underscores the elimination of waste. It is focused on eradicating non-value adding activities, boosting the efficiency of value adding ones all while reducing costs. Since demand from the base stream is predictable, the sponsor company can manufacture goods in anticipation of demand with reasonable assurance that they won’t end up sitting on a surplus of inventory.

According to Davies (2012), “as a result planning can be based on the average rate of demand for the product. This in turn helps companies to level load the factory with consistent and preplanned manufacturing runs, thereby better managing capacity and production operations.” The recommended strategy for how to deal with base demand as a standalone stream is in-line with the literature reviewed herein.

Since the promotional and IBA streams exhibited only level with no observable trend, the simple exponential smoothing method was used to create their forecasts. The plots below represent the forecasted versus actual values for each of the two streams, each period represents a week.

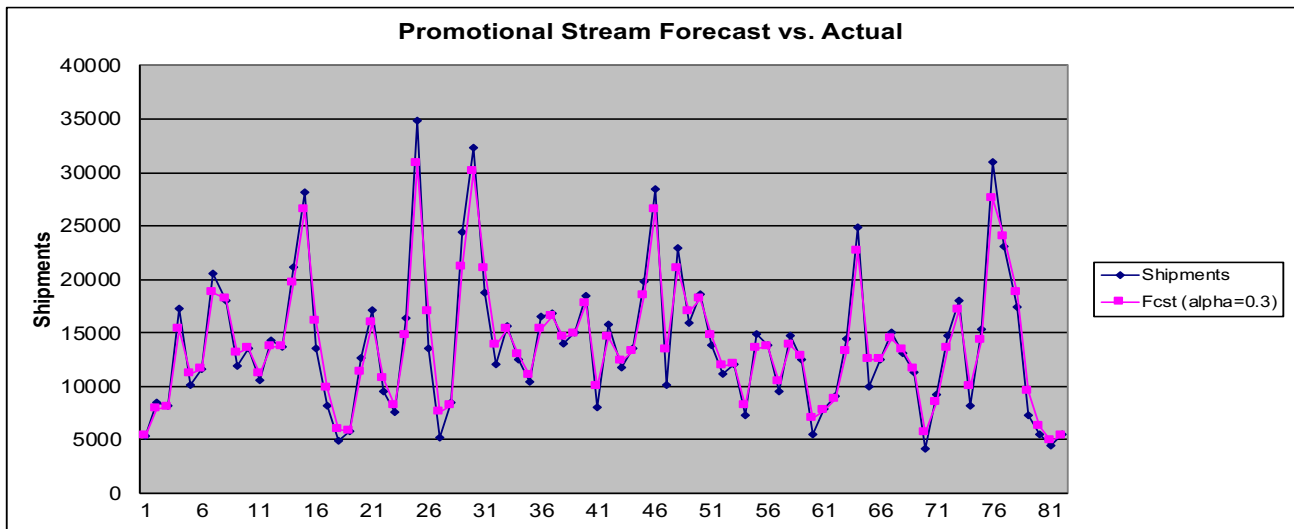


Figure 8: Promotions Forecast Vs. Actual

Similar to base demand, the MAPE for the promotional and IBA streams were calculated and are 33% and 256% respectively. This is unsurprising as a high coefficient of variation (calculated at 71% for promotional and 168% for IBA) is indicative of a high level of forecast error (Mant, 2001). If treated individually, these streams would benefit from collaborative planning, forecasting and replenishment (CPFR). CPFR is a concept that “combines the intelligence of multiple partners in the planning and fulfillment of customer demand (Chopra and Meindl, 2007).” CPFR requires manufacturers and retailers to collaborate in the management of inventory through sharing information in the quest to meet the needs of the end customer. The motivating factor is that the parties in the supply chain are working off of the same forecast therefore reducing demand variance. According to Blecker, Kersten, and Meyer (2010) “this allows for continuous updating of inventory and upcoming requirements, making the end-to-end supply chain process more efficient.” In the Colgate-Palmolive case study assessed in the literature review, the authors

determine that for high volume, high volatility SKUs an organization should pursue collaborative planning, forecasting, and replenishment.

CPFR makes sense in a demand profile characterized by high volatility, such as the promotional and IBA streams. The strategy would not be a fit for a stream like base demand that is characterized by a stable demand signal. If distinguishing the supply chain by the individual streams and treating them differently, implementing CPFR for the promotional and the IBA stream would provide a high degree of agility and lead to a decrease in safety stock and average inventory as it provides an effective way to anticipate customer demand. Through not explicitly stated, it is evident that the sponsor company has implemented CPFR for the promotional stream as it collaborates with customers to gather demand planning information four to six weeks in advance. The same cannot be said for IBAs as the sponsor company characterizes this stream as having unplanned demand spikes that occur with very little notice. The IBA stream could benefit from the sharing of information and joint visibility that CPFR affords.

Demand for the optimal hybrid of streams; base demand, promo, and IBA, was aggregated in order to create a forecast. The aforementioned hybrid of streams exhibited both level and trend, therefore the Holt's model was used to generate forecasted values. Similar to base demand, the

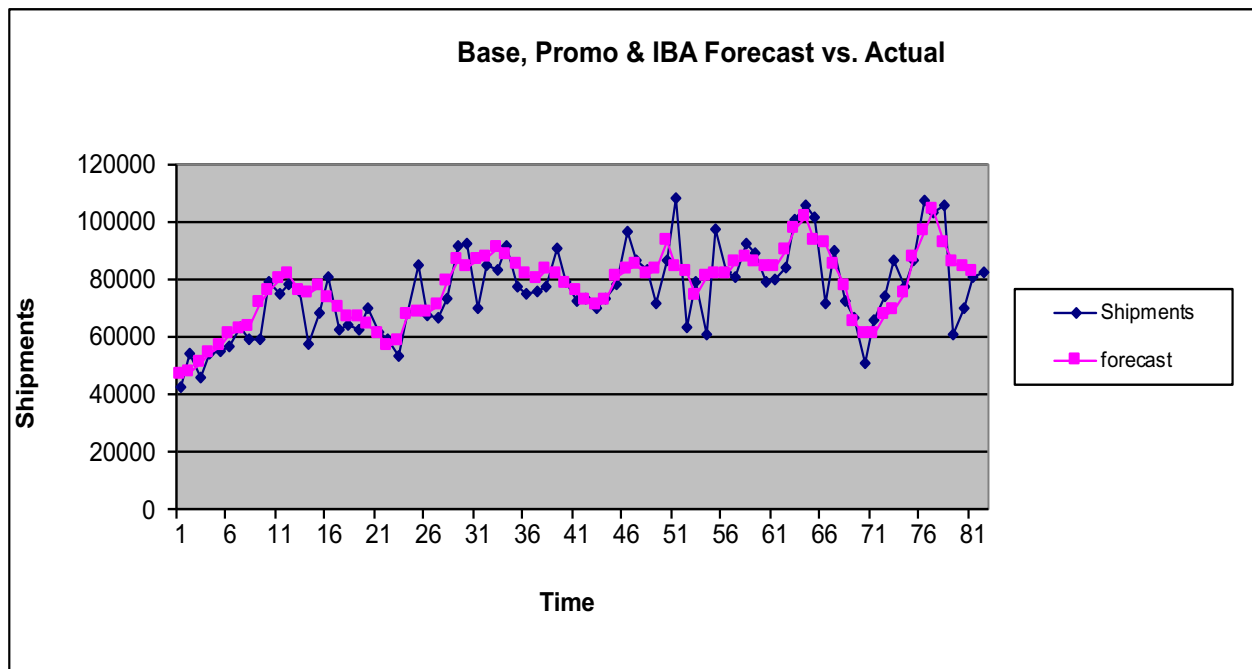


Figure 9: Base, Promo, IBA Forecast Vs. Actual

MAPE calculated for this hybrid of streams is also approximately 9%. This figure was unsurprising for two reasons; (1) base demand serves as its driving force as it accounts for 73% of total

shipments and (2) the hybrid of streams had the lowest coefficient of variation at 31.6% and as previously mentioned, a low coefficient of variation is indicative of a low forecast error.

Aggregating or pooling the demand by the identified optimal hybrid of streams will lead to improved forecast accuracy and therefore lower safety stock since demand will be stabilized. Lower safety stock means lower average inventory on hand. By pooling demand and therefore reducing uncertainty, a corporation can reduce inventory without negatively affecting customer service level or product availability (Oeser, 2015). According to Godsell et al. (2009) “stable demand is the easiest to plan for, and the cheapest to produce as the requirements for buffers (e.g. spare capacity or inventory) are minimized. It therefore benefits both the supply chain and the customer, as supply is reliable and low cost.” This means that the sponsor company will not have to protect itself (by increasing safety stock) from the variability inherent in treating each stream separately. Additionally, by consolidating the streams the sponsor company can streamline operations and eliminate the administrative costs that would result from managing each stream separately. Based on this, adopting a lean strategy (similar to that described for the base demand stream) would be best if differentiating the supply chain by the identified optimal hybrid of streams.

The decision tree in figure 10 highlights when it is beneficial to pool and concisely delineates the strategies discussed herein.

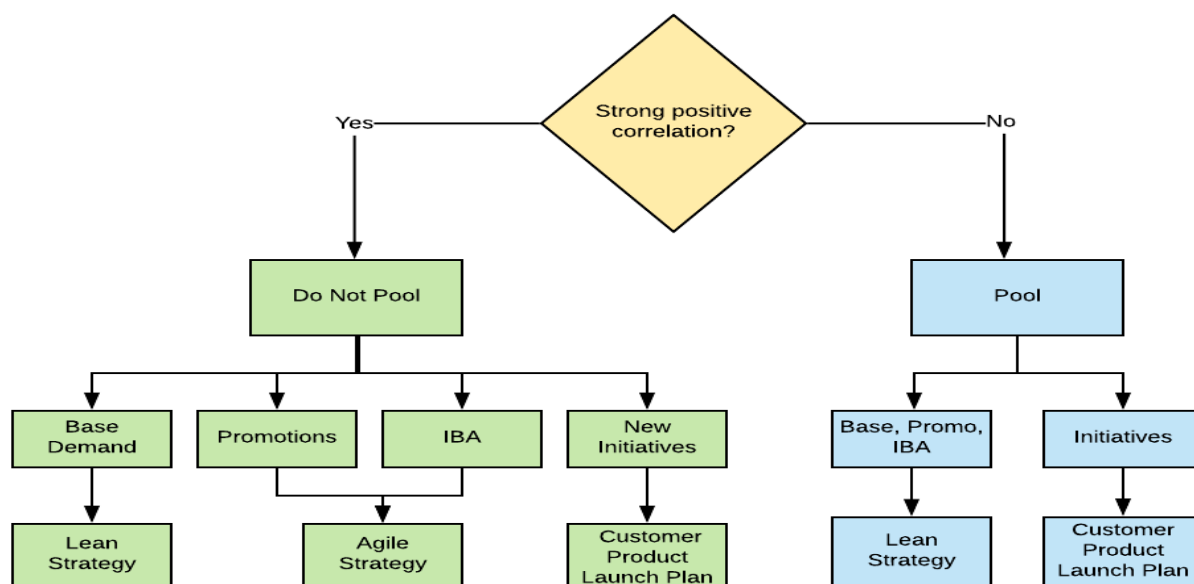


Figure 10: Demand Strategy Decision Tree

4.2 Distribution Strategy

There are 4 distinct distribution strategies; direct shipment, warehousing, cross docking, and transshipment (Simchi-Levi and Kaminsky, 2007). An effective distribution strategy streamlines a company's operations and ensures customer satisfaction through high service levels. As discussed in the methodology section, the sponsor company's strategic choice in regards to distribution is centered around ensuring a high level of customer service. A measure of customer service level is the case fill rate. The sponsor company aims for a case fill rate greater than 98% for its top customers. With this in consideration, the data was segmented by SKU, customer, and the percent of shipment by stream and customer in order to arrive at an appropriate distribution strategy that takes into account the four replenishment streams. The case fill rate for the identified top customers was computed and the sponsor company's distribution network was also mapped in order to understand how it employs direct shipment, warehousing, cross docking and transshipment. This section discusses the results from the aforementioned calculations and applies them in the formulation of a distribution strategy in consideration of the four replenishment streams.

4.2.1.1 Distribution Network Mapping

As delineated in the methodology section 3, I mapped out the sponsor company's distribution network including the manufacturing plants and mixing centers as seen in figure 11. The plants, depicted in blue, are where the products are manufactured. Plant 1 serves as a push site where products are made and immediately shipped via full truckload either to the mixing centers or plant 2. Plant 2 serves as both a manufacturing center and a centralized supply warehouse. The products received from plant 1 stay in

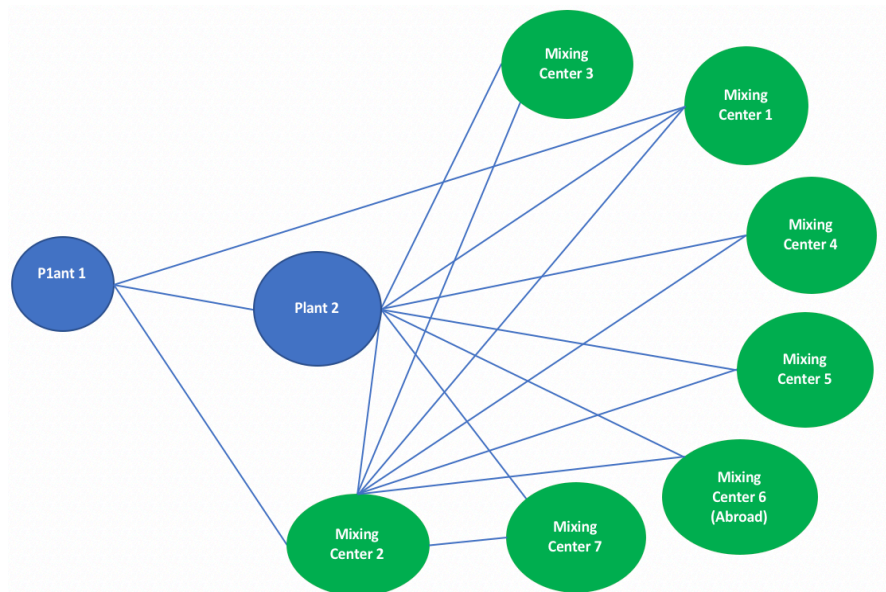


Figure 11: Distribution Network Map

plant 2 then are shipped to the mixing centers when triggered by customer orders. The mixing centers, depicted in green, are where items from the manufacturing plants are consolidated per customer order and deployed to the retailers under one invoice. With 6 mixing centers located in the United States and one abroad, the sponsor company's puts a premium on responsiveness with a supply network strategically designed to distribute 80% of its U.S. demand to stores within 24 hours.

In the mixing center other activities such as product customization, assembly of instore displays and promotional packaging also take place. Interplant shipment or transshipment also takes place within the mixing center. With the transshipment strategy, orders are shipped between different facilities at the same level in the supply network in order to meet urgent needs or consolidate shipments for the end customer.

The mixing centers also employ a cross docking strategy which allows them to ship to customers within a day. With the cross-docking strategy, inbound goods from plant 1 or plant 2 arrive at the mixing center and are moved to the outbound lane. This strategy is time efficient as it reduces the number of touches by bypassing warehouse storage and the picking function.

A visit to one of the mixing centers revealed that the frequency for weekly shipments per customer for the top customers increased from approximately 2 to 10 deliveries within the past few years. Per the sponsor company, this allows it to be more responsive as more deliveries in smaller quantities ensure that the customer has what they need. Within the span of a day, this particular mixing center can load up to 400 trucks or 16,000 pallets.

4.2.1.2 Minimum Order Quantity

The sponsor company has varying minimum order quantity (MOQ) constraints by replenishment stream. An MOQ constraint indicates the lowest quantity that a vendor is willing to sell and is usually expressed in units (Vermorel, 2016). The sponsor company ships its merchandise by pallet, pallet layer, and case pick. The merchandise can be strategically combined in order to fulfill a customer's order.

For the base demand replenishment stream, the sponsor company stipulates that approximately 50% of a customer's order must be pallet with about 20% case pick. According to the sponsor company about 54% of merchandise shipped for the promotional stream is in display ready pallets with the rest shipped in bulk case. New initiatives and incremental business

activities depend on the customer order and lead time. For shorter lead times, they are usually shipped in pallet layers or cases but otherwise they are usually shipped in pallets or pallet layer.

4.2.1.3 Segmentation

As discussed in the methodology section, segmentation is a requirement for effective strategy formulation. Therefore, segmentation of customers was done in order to classify the vital few customers that have the greatest impact in shipment volume from the trivial many.

As anticipated and as seen in the customer Pareto chart in figure 12, a small percentage of the customers drive a majority of the shipment volume for the sponsor company with

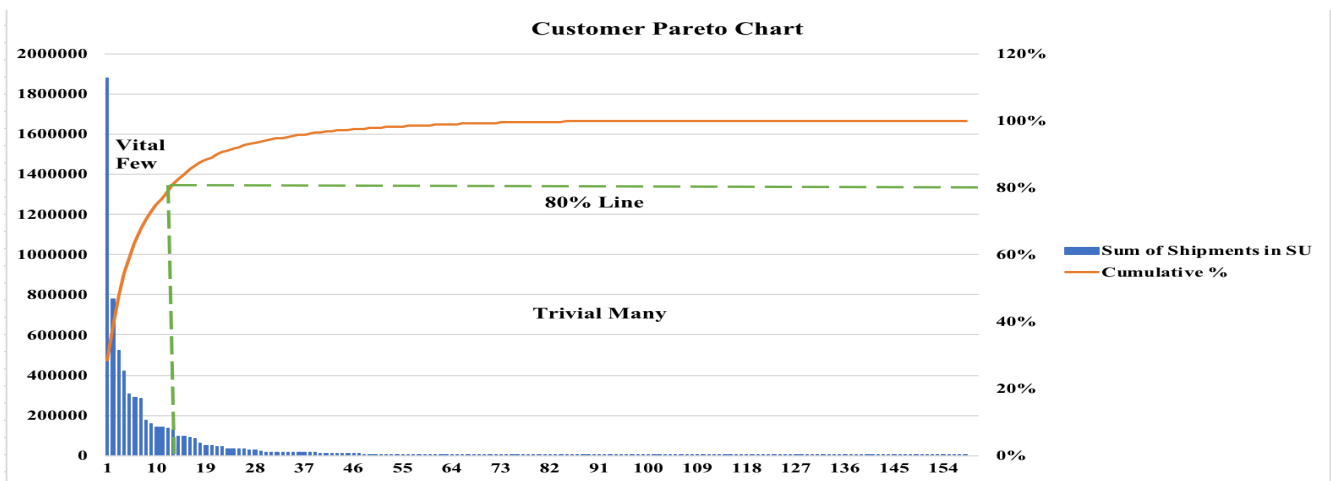


Figure 12: Customer Pareto Chart

shipment quantity is separated by stream, it becomes apparent which customers have the greatest influence on each stream. As seen on figure 13, customer 1 is responsible for 74% of the initiative

% of Shipments by Stream per Customer					
Customer Rank	Base Demand	IBA	Initiatives	Promo	Grand Total
1	32.1%	2.4%	74.3%	7.6%	28.4%
2	2.8%	26.5%	3.9%	48.2%	11.8%
3	7.6%	8.8%	1.0%	10.6%	7.9%
4	7.6%	12.3%	2.2%	0.9%	6.4%
5	5.0%	0.0%	1.3%	5.3%	4.6%
6	3.7%	23.1%	0.0%	3.5%	4.3%
7	3.8%	6.5%	4.7%	6.0%	4.3%
8	3.4%	0.0%	1.4%	0.7%	2.7%
9	2.7%	0.0%	1.7%	1.9%	2.4%
10	2.4%	0.1%	0.9%	2.3%	2.2%
11	2.8%	0.1%	0.7%	0.2%	2.1%
12	2.4%	0.6%	3.1%	0.7%	2.1%
13	1.6%	14.1%	0.0%	0.9%	2.0%
14	1.6%	0.4%	0.0%	1.6%	1.5%
15	1.7%	1.7%	0.0%	0.8%	1.4%

Figure 13: % of Shipments by Stream per Customer

stream while customer 2 is responsible for 48% of promotions. Additionally, the top 7 customers drive 82% of promotional events, the top 13 customer drive 95% of IBA events, and the top 15 customers drive roughly 80% of base demand events.

4.2.1.4 Case Fill Rate

Through a segmentation of the customers, I found that roughly 80% of total shipments were being driven by 15 or 10% of all customers. Since the sponsor company aims for a case fill



Figure 14: CFR for Top 15 Customers

rate (CFR) of 98% or greater for its top customers, I calculated the CFR for the top 15 customers and found that only 8 of the top 15 customers have a CFR greater than 98%. For each of the top customers, I analyzed which demand stream contributed most to CFR loss. I found that the CFR loss per stream for all but one customer ranged from 0-2%. As seen in figure 15, customer 6 has the highest CFR loss stemming from the IBA stream at 5% but also happens to have the second highest IBA shipment as evident on figure 13. Customer 2, with the highest IBA shipment, has a CFR loss for the IBA stream of only 0.1%. Therefore, it behooves the sponsor company to apply some of the learnings contributing to customer’s 2 low CFR for the IBA stream to customer 6.

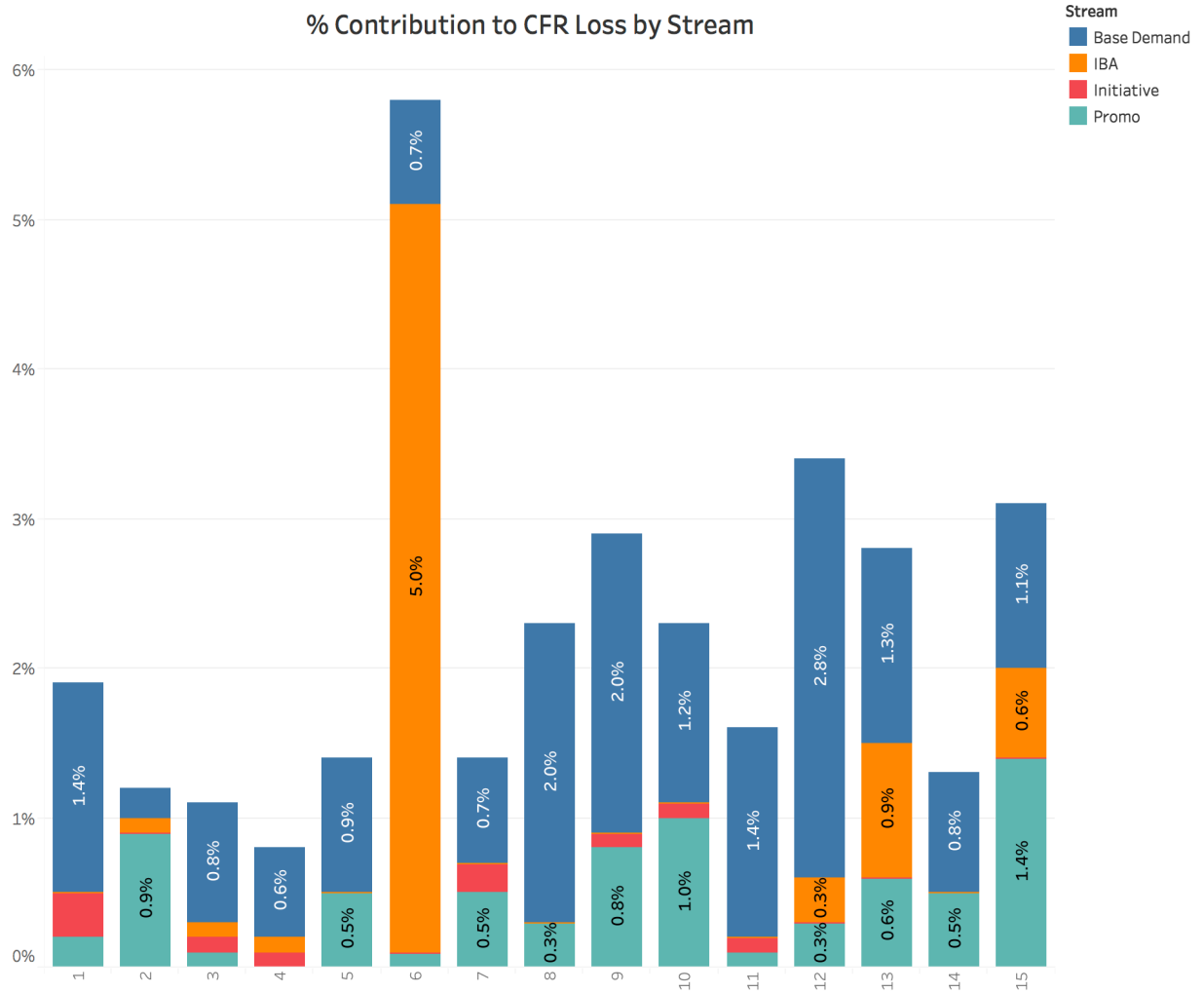


Figure 15: % Contribution to CFR Loss by Stream for Top 15 Customers

4.2.2 Recommendation

The above results raise the question as to whether or not it is necessary to treat the streams the same in setting the distribution strategy or to differentiate them in order to optimize the service level for its customers at a low cost. After further evaluation and a deep dive into the data, I recommend that the sponsor company separates the 4 replenishment streams into three buckets. The first bucket is the base demand stream as it is characterized by a steady flow and therefore would benefit from a lean distribution strategy. The second bucket contains the new initiatives stream under an agile distribution strategy. The third bucket pools the promotions and the incremental business activity (IBA) streams under a lean-agile or “leagile” distribution strategy to mitigate variances in demand.

Under a lean distribution strategy, products under the base demand stream can be made to stock and orders can be satisfied from finished goods inventory on hand. Since demand from the base stream is predictable, the sponsor company can manufacture goods in anticipation of demand with reasonable assurance that they won't end up sitting on a surplus of inventory. Through customers segmentation, I found that roughly 15 customers drive approximately 80% of the base demand shipments with the top customer being responsible for 32% of total base demand shipments. Therefore, the sponsor can strategically store inventory for the base demand stream in mixing centers that regularly services those particular customers. For this, the sponsor company can maintain the same minimum order quantity as it currently has with approximately 50% of a customer's order being pallet orders with about 20% case pick. The sponsor company will be able to maintain its high service levels for the base demand stream since this strategy does not deviate from the one that the sponsor company already has in place.

An agile strategy is characterized by flexibility as it aims to maintain a competitive advantage in a dynamic landscape by providing products tailored to unique customer specifications to the market quickly. This strategy would be optimal for the new initiatives stream. As previously mentioned, new initiatives are driven primarily by the customer launch plan. Under this stream, new stock keeping units (SKUs) are brought to market for the first time. A new SKU is defined by the sponsor company as either an entirely new product or as an iteration of an existing product but with improved features. An analysis of the data indicates that 95% of shipments under the new initiatives stream are driven by the top 12 customers with the customer ranked as number #1 being responsible for 74% of those shipments. For the customer driving 74% of shipments under the new initiatives stream, the sponsor has two options; (1) it can either directly ship the product to the customer contingent on transportation costs and shipment volume or (2) it can ship from the plant straight to the mixing centers. For the second option, the products would arrive at the mixing center's inbound lane and be cross docked to the outbound lane for shipment on the same day. At the mixing center, they can be consolidated with other products being shipped to the end customer. Both of these options do not necessitate storing the products in a warehouse and therefore decreases inventory holding costs. These options also increase the service level as they reduce the number of touches by passing the warehouse storage and picking functions. The tradeoff from option one is an increase in transportation costs therefore, it should be noted that option one is best for customer one only if there are enough products for a full truck load. The remaining 26% of

shipments under the initiative stream are fragmented between customers. Therefore, I would recommend option two for the rest of the customers.

Since promotion and IBA streams together only make up 22% of total shipments, pooling them under a lean-agile or “leagile” strategy that employs postponement would allow the sponsor company to streamline operations by condensing the amount of resources it uses to manage each stream individually. A lean-agile or “leagile” hybrid combines both lean and agile paradigms. A “leagile” approach calls for lean operations in the production of generic, semi-finished product, and agile accommodation in the customization process (Mason-Jones, Naylor, and Towill 2000). It allows the sponsor company the ability to accommodate diverse customer needs efficiently by delaying the final form of a product until an order or warning signal is received from the customer dictating the type and quantity of the goods demanded. This approach works best for merchandise that is manufactured from common materials into a near-finished state—similar to the product being evaluated under this project.

As previously mentioned, the mixing centers are where items from the manufacturing plants are consolidated per customer order and deployed to the retailers under one invoice. In the mixing center, other activities such as product customization, assembly of instore displays and promotional packaging take place. Therefore, I recommend that the generic form for the products under the pooled IBA and promo streams be held at the mixing centers and customized accordingly when the demand signal is received. This strategy leverages the use of the resources and the processes that the sponsor company already has in place. By pooling the two streams thereby reducing variability, the sponsor company has the opportunity to reduce inventory without negatively affecting customer service level or product availability.

4.3 Sourcing Strategy

In the formulation of a sourcing strategy, it is important to note that the four replenishment streams are not a property of the SKU. Over the span of a year, a SKU can be phased in as a new initiative, transitioned into base demand and have some promotional activity with heavy shipments during its life cycle. Since a SKU can occupy any of the four streams, it does not make sense to differentiate the supply chain by the four identified replenishment streams in regards to the sourcing strategy.

4.3.1 Recommendation

Based on the above, I recommend that the sourcing decision should not be distinguished by the four replenishment streams but rather, it should be based on the variability and volume of individual SKUs. Furthermore, treating the streams the same would allow the sponsor company to leverage economies of scale when sourcing raw materials.

Therefore, in the formulation of a sourcing strategy, I segmented the SKUs so as to classify the vital few SKUs from the trivial many. From the segmentation, I found that “A” SKUs or approximately 12% of SKUs represent about 80% of total shipment as seen on the SKU Pareto chart in figure 16. “B” SKUs or approximately 17% of SKUs make up 15% of shipments while

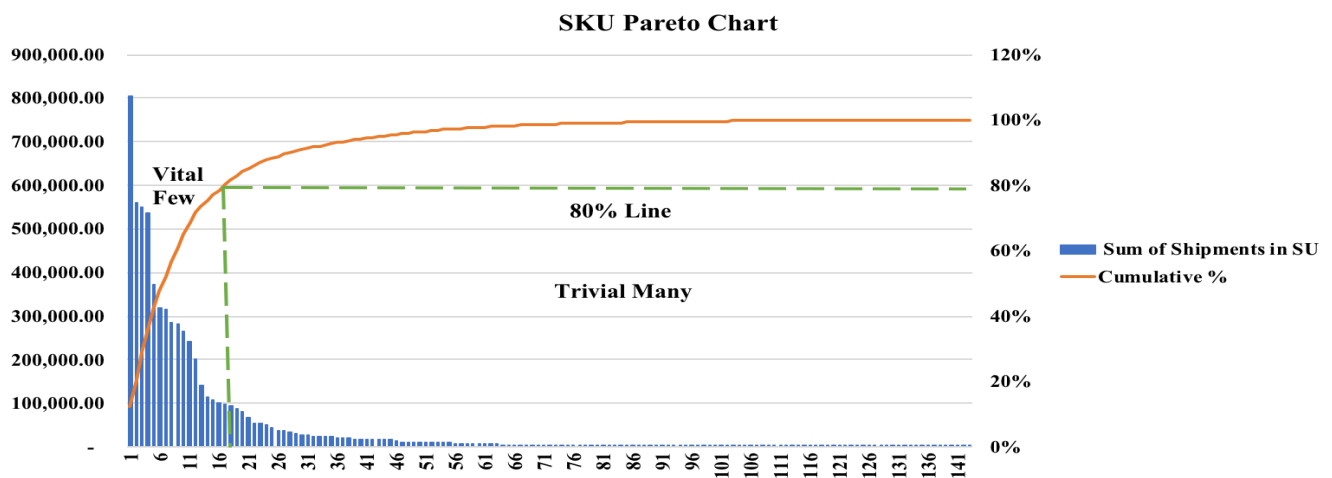


Figure 16: SKU Pareto Chart

the remaining 71% of SKUs or “C” SKUs account for the last 5% of shipments. This follows the Pareto principle where a small number of SKUs drives a majority of the shipments. It should be noted that the top SKUs can change from year to year depending on the shipment volume and therefore SKU segmentation should be done yearly.

I also calculated the variability of each SKU using the coefficient of variation and plotted it against the weekly shipment volume per SKU. Figure 17 displays a volume and variability profile with each dot representing a SKU. As seen on Figure 17, the SKUs that drive a majority of the shipments (furthest to the right) have less variability with the adverse being true for lower volume SKUs which are concentrated to the left of the plot. Through this analysis, I learned that the top 12% of SKUs that also represent about 80% of total shipments are represented by the dots furthest to the right as they have the lowest variability. Based on this analysis, my recommended approach would be to source materials for the high-volume, low-variability SKUs

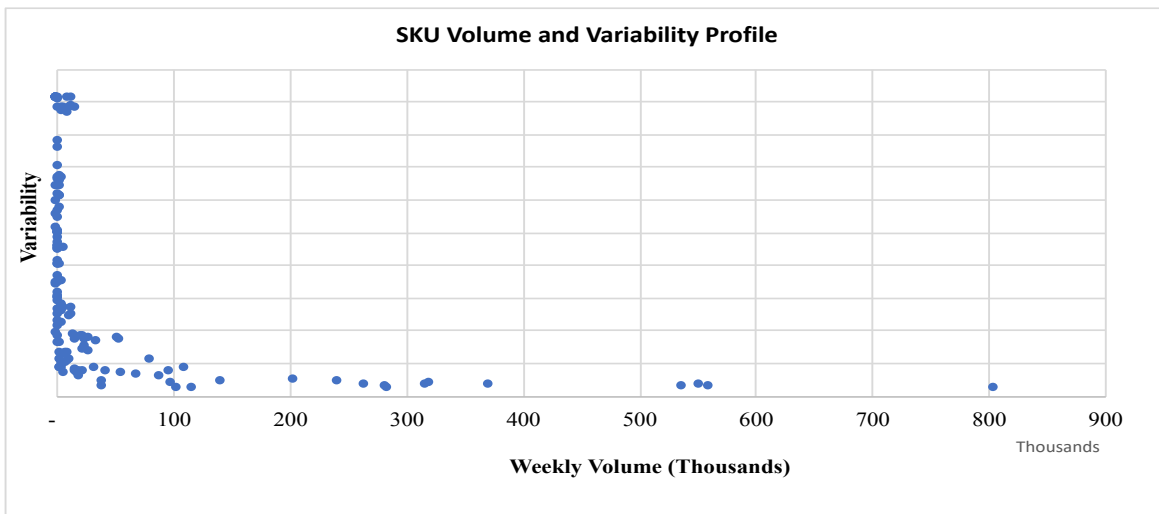


Figure 17: SKU Volume and Variability Profile

or the “A” SKU’s from distant low-cost sources since demand for them is more stable. This should be evaluated against lead time and transportation costs. Contracts for raw material for these SKUs should be strategic and long term to reduce risks.

As aforementioned, “B” and “C” SKUs, as characterized by their high volatility and low volume, make up the remaining 20% of shipments. In order to maintain agility in the supply chain, my recommendation is that these remaining SKUs be sourced closer to market. Since they are highly volatile, sourcing them closer to market will increase the sponsor company’s customer responsiveness therefore minimizing lost sales. In addition, sourcing “B” and “C” SKUs together will allow the sponsor company to be able to leverage economies of scale.

The new initiatives stream depends on the customer’s launch plans and thus requires agility. Under this stream, new stock keeping units (SKUs) are brought to market for the first time. Therefore, in order to ensure that SKUs with activity in this stream are being captured in

% of Shipments by Stream and SKU					
SKU Rank	Base Demand	IBA	Initiatives	Promo	
1	83%	4%	0%	13%	
2	79%	3%	0%	18%	
3	80%	4%	0%	15%	
4	80%	2%	0%	18%	
5	80%	3%	0%	18%	
6	91%	2%	0%	7%	
7	75%	4%	0%	21%	
8	81%	3%	0%	16%	
9	80%	5%	0%	14%	
10	78%	6%	0%	16%	
11	57%	11%	0%	31%	
12	59%	3%	0%	37%	
13	50%	6%	0%	44%	
14	84%	2%	0%	13%	
15	57%	25%	0%	15%	
16	75%	7%	0%	18%	
17	64%	6%	0%	30%	

Figure 18: % of Shipments by Stream and SKU

the more agile strategy, the one for “B” and “C” SKUs as aforementioned, I separated the percentage of shipments by stream and SKU. By doing this, I discovered that the top 12% of SKUs (or “A” SKUs) that drive 80% of the total shipments do not have any activity in the initiative stream as seen on figure 18. This means that the activity in the initiative stream happens in the remaining SKUs (or “B” and “C” SKUs). Therefore, the agility necessary for this stream is captured under the aforementioned strategy.

The decision tree in figure 19 below concisely summarizes the above recommended sourcing strategy.

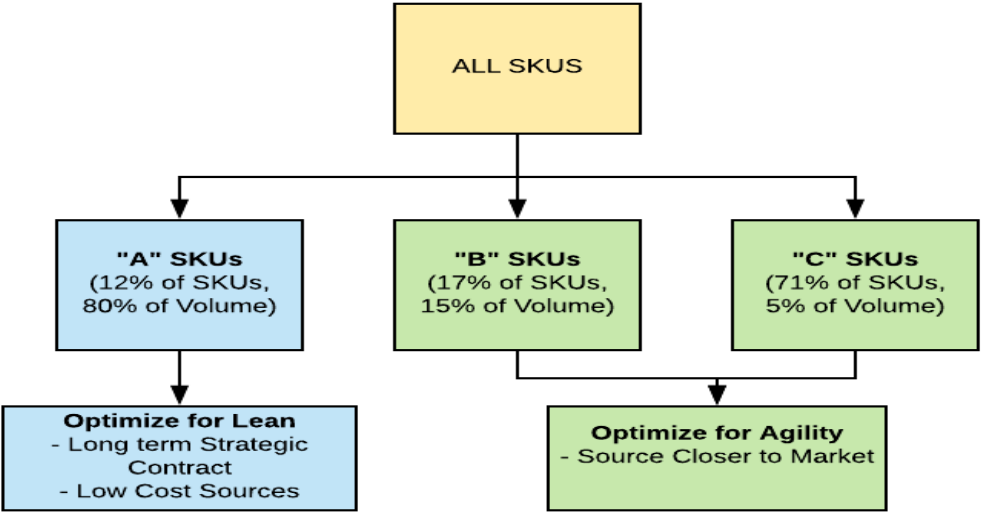


Figure 19: Sourcing Strategy Decision Tree

5. Conclusion

An analysis of the shipment data provided coupled with existing literature reveals that there is no one size fits all demand, sourcing, and distribution strategy in consideration of the different replenishment streams. Through a variety of methods including segmentation, calculation of the coefficient of variation, time series analysis, and the generation of forecasts, I conclude that in certain instances there is a benefit to differentiating the supply chain by the 4 identified replenishment streams. In other cases, it is advantageous to consolidate them by some hybrid. These instances are highly dependent on the data and are subject to change year over year depending on the needs of the customers.

Below is a summary of the conclusions drawn from the analysis conducted in this project. This analysis is done in consideration of the replenishment streams with respect to demand, distribution, and sourcing category operating strategies.

5.1.1 Demand

The sponsor company has the option to pool or not pool the streams depending on whether the streams are negatively or positively correlated. The more positively correlated the streams are, the less beneficial it is to pool since there is no decrease in uncertainty or variability.

If the replenishment streams do not exhibit a strong positive correlation, then I recommend consolidating demand by the optimal hybrid of streams identified as base demand, promotional, and incremental business activity streams. Aggregating demand by this identified optimal hybrid of streams will lead to improved forecast accuracy and therefore lower safety stock since demand will be stabilized. Lower safety stock means lower average inventory on hand. Pooling demand and therefore reducing uncertainty will enable the sponsor company to reduce inventory without negatively affecting customer service level or product availability. Additionally, by consolidating the streams the sponsor company can streamline operations and eliminate the administrative costs that would result from managing each stream separately. Based on this, adopting a lean strategy would be best if differentiating the supply chain by the identified optimal hybrid of streams.

If the supply chain was to be differentiated by the four streams and each stream was treated individually due to a strong positive correlation, then it would be beneficial for the sponsor company to adopt a lean strategy for the base demand stream since demand under this profile is

stable. I recommend an agile strategy for the for the IBA and promotional streams. As discussed in section 4 herein, implementing collaborative planning forecasting and replenishment (CPFR) for the promotional and the IBA streams would provide a high degree of agility and lead to a decrease in safety stock and average inventory as it provides an effective way to anticipate customer demand. CPFR would allow the sponsor company and retailers to collaborate in the management of inventory through sharing information in the quest to meet the needs of the end customer.

5.1.2 Distribution

In summary, I recommend that the sponsor company separates the 4 replenishment streams into three buckets for the distribution strategy. The first bucket is the base demand stream as it is characterized by a steady flow and therefore would benefit from a lean distribution strategy. The second bucket contains the new initiatives stream under an agile distribution strategy. The third bucket pools the promotions and the incremental business activity (IBA) streams under a lean-agile or “leagile” distribution strategy that employs postponement and mitigates variances in demand.

Under a lean distribution strategy, products under the base demand stream can be made to stock and orders can be satisfied from finished goods inventory on hand. Since demand from the base demand stream is predictable, the sponsor company can manufacture goods in anticipation of demand with reasonable assurance that they won’t end up sitting on a surplus of inventory. Through customers segmentation, I found that roughly 15 customers drive approximately 80% of the base demand shipments with the top customer being responsible for 32% of total base demand shipments. Therefore, the sponsor can strategically store inventory for the base demand stream in mixing centers that regularly services those particular customers. The sponsor company will be able to maintain its high service levels for the base demand stream since this strategy does not deviate from the one that the sponsor company already has in place.

The new initiatives stream would benefit from the flexibility inherent in an agile strategy because under this replenishment profile, new stock keeping units are brought to market for the first time. Since one customer drives 74% of the activity in the new initiatives stream, the sponsor company has 2 options; (1) it can either directly ship the products to the customer contingent on transportation costs and shipment volume or (2) it can ship from the plant straight to the mixing centers. For the second option, the products would arrive at the mixing center’s inbound lane and

be cross docked to the outbound lane for shipment on the same day. At the mixing center, the products can be consolidated with other merchandise being shipped to the end customer. Both of these options do not necessitate storing the products in a warehouse and therefore decreases inventory holding costs. These options also increase the service level as they reduce the number of touches by passing the warehouse storage and picking functions. The tradeoff from option one is an increase in transportation costs therefore, it should be noted that option one is best for customer one only if there are enough products for a full truck load. The remaining 26% of shipments under the initiative stream are fragmented between customers. Therefore, I would recommend the aforementioned option two for the rest of the customers.

Since promotion and IBA streams together only make up 22% of total shipments, consolidating them under a lean-agile or “leagile” strategy that employs postponement would allow the sponsor company to streamline operations by condensing the amount of resources it uses to manage each stream individually. This strategy calls for lean operations in the production of generic, semi-finished product, and agile accommodation in the customization process. I recommend that the generic form for the products under the pooled IBA and promo streams be held at the mixing centers and customized accordingly when the demand signal is received. This strategy leverages the use of the resources and the processes that the sponsor company already has in place. By pooling the two streams thereby reducing variability, the sponsor company has the opportunity to reduce inventory without negatively affecting customer service level or product availability.

5.1.3 Sourcing

In the formulation of a sourcing strategy, it is important to note that the four replenishment streams are not a property of the SKU. Since a SKU can occupy any of the four streams, it does not make sense to differentiate the supply chain by the four identified replenishment streams in sourcing for products that use similar materials. Treating the streams the same would allow the sponsor company to leverage economies of scale when procuring raw materials. Therefore, I recommend that the sourcing decision should be based on the variability and volume of individual SKUs.

To summarize, my recommended approach would be to source materials for the high-volume, low-variability SKUs or the “A” SKU’s, representing 80% of volume and only 12% of SKUs, from distant low-cost sources since demand for them is more stable. This should be

evaluated against lead time and transportation costs. Contracts for raw material for these SKUs should be strategic and long term to reduce risks. “B” and “C” SKUs, as characterized by their high volatility and low volume, make up the remaining 20% of shipments. In order to maintain agility in the supply chain, I recommend that these remaining SKUs be sourced closer to market. Since they are highly volatile, sourcing them closer to market will increase the sponsor company’s customer responsiveness therefore minimizing lost sales. In addition, sourcing “B” and “C” SKUs together will allow the sponsor company to leverage economies of scale.

5.2 Future Areas of Research

As online shopping becomes more prevalent, the sponsor company is tasked with meeting service and efficiency obstacles across multiple channels. Therefore, an area for further research would be segmenting ecommerce and traditional brick and mortar stores and investigating how the recommended operating strategies are affected in consideration of the 4 replenishment streams.

In regards to the demand strategy, as discussed herein, it is not beneficial to pool the streams together if they exhibit a strong positive correlation. An area for future enhancement and further research to this strategy would be calculating the threshold for the mean absolute percentage error (MAPE) where it would also not make sense to pool the streams.

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