Modeling the Impact of Complexity on Transportation

Summary: In this research, we examined the behavior of transportation costs during supply chain complexity events, in particular, new product launches in the distribution network of an FMCG manufacturer. We analyzed the cost-to-serve a customer in the network, recommended a method for picking the lowest transport cost factory and analyzed how these costs change with carrier mix and seasonality. This should enable transportation planners make better transport allocation decisions. Finally, we recommended strategic, tactical and operational steps for managing transportation costs during complexity events.

KEY INSIGHTS

1. A backfill distribution strategy significantly alters the relative impact of each component in the total transportation cost equation.

2. A cost-to-serve analysis and the development of a priority allocation matrix can help transportation planners re-examine and improve the day-to-day decision making process during supply chain complexity events.

3. The impact of supply chain complexity events on total transportation cost variability increases more in the high season than in the low season for each factory location.

Introduction

Companies in the fast moving consumer goods (FMCG) industry rely on a network of customers to distribute their products to the end consumer. They aim to transport their products (typically via trucks) in a speedy and cost efficient way. This is especially challenging during unexpected fluctuations in the demand (for products) and supply (of transportation capacity). These unexpected variations, or complexity events, are often characterized by additional shipments and therefore additional costs. Typical efforts by transportation planning teams to minimize these costs, such as routing guide enforcement, may still not achieve optimal costs for the total transportation system.

Our research focuses on a specific type of complexity event: the launch of new products. During this type of event, the transportation departments of companies typically have very little time to react to a sudden spike in demand. This can lead to less than optimal transportation capacity allocation decisions, such as selecting a more expensive transport carrier or servicing a customer from a more expensive factory location.

The goal of our research was to identify the principal drivers of these changes and to understand their behavior. We also proposed criteria for making optimal transportation allocation decisions during complexity events. We examined these issues from the perspective of CPGCo, a major player in the FMCG market in the United States.
Research Scope
CPGCo distributes its products through a network of over 500 customers spread across the United States. It operates a series of factories and distribution centers that ensure the supply of over 50 stock keeping units (SKUs) to these customers. Each factory usually supplies key brands to the closest customers. New products are launched from a single factory location and distributed to all the customers in the network, in many cases bypassing the factories that traditionally supply certain customers. Also, factories not launching products may take up the supply of mature products to customers traditionally supplied by the launch factory. We refer to this as a backfilling strategy.

We studied the impact of these dynamics on the total transportation costs in the distribution network during a new product launch. Figure 1 shows the supply and demand dynamics that take place during a new product event. Our analysis focused on the costs generated from operating a non-dedicated fleet. We used actual shipment volume and cost data from CPGCo shipments to conduct the analysis. All shipment volume, cost, factory and customer location data discussed in this document have been disguised to protect CPGCo’s proprietary data.

Figure 1: Supply and Demand Dynamics during new product launches

Research Approach
Our research started with structured interviews with transportation planning managers at CPGCo to understand transportation operations in the company. These were complemented by interviews with transportation planning managers from other industries to understand how they specifically manage the impact of supply chain complexity events in their companies.

In our research, we evaluated each component of the total transportation cost equation for truckload transportation to determine the key drivers during supply chain complexity. We focused on nationwide truckload moves of CPGCo’s dedicated fleet in 2011.

We proceeded to analyze the following drivers: transportation rates, load volume, regional factors and length of haul. All cost elements were restricted to the line haul components of the total cost of a move. Thus, the contribution of fuel surcharges, accessorial costs and stop charges were excluded. The behavior of each cost driver was compared under two scenarios: events and non-events. “Events” referred to periods in the year in which new product development activities took place. These included new product launches and promotions. We assumed that a typical pipeline filling lasted on average five weeks during events. We performed a deterministic analysis using basic descriptive statistics to determine the general behavior of each driver during supply chain complexity events. We then developed a model to help predict the expected range and variability of total transportation costs during these events.

Analysis 1: Transportation Rate
Our research showed that the average rates on each origin-destination pair changes with the carrier mix on each lane. This is despite strong routing guide enforcement, which keeps the rate charged by each carrier constant on each lane throughout the year. During new product launch events, increased load rejection by carriers simply increases the routing guide depth at CPGCo.
We also analyzed the behavior of transportation rates across the following dimensions: carrier level, factory level, event factory level, long haul lanes and short haul lanes. However, the results obtained for each of these analyses was inconclusive and could not be used to reliably predict total transportation cost behavior during new product launch events.

**Analysis 2: Shipment Volume**

We also analyzed the change in the frequency of shipments during events at CPGCo, to determine what effect it would have on total transportation costs. We observed only one occasion where there was an increase in the number of shipments at a factory during events. In most cases, there was no visible change in the number of shipments originating from a factory during an event.

Our investigations reveal that the only occasion with a matching increase in shipments during an event, was unrelated to any specific new product launch activity. Our interviews also showed that CPGCo employed a backfill strategy during new product launch events. This ensured that shipping volume requirements were simply redistributed throughout the distribution network with minimal changes (if any) at each individual factory location.

**Analysis 3: Regional Effects**

Our analysis of the impact of regional factors during product launch events at CPGCo was also inconclusive. The impact of regional factors is usually captured in the rates presented by individual carriers during the bidding process. While in some cases the backfill strategy required shipments from a cheaper to a more expensive region, this did not take place in all cases.

**Analysis 4: Length of Haul**

Our study showed that the backfill strategy resulted in longer distances being covered by each factory during an event at CPGCo. See Figure 2 shows the observed dynamics.

![Figure 2: Distribution dynamics during events and non-events at CPGCo](image)

Launch factories are responsible for distributing new products to all the customers in the distribution network during new product launch events. Also, non-launch factories are sometimes responsible for meeting the supply of mature products to customers of the launch factory during this time. In one factory for example, a total of 43 new lanes were added during an event, while 40 existing lanes were temporarily dropped during an event.

For the purpose of this study we excluded the impact of other costs such as fuel surcharges, accessorial costs, stop charges and loading/unloading charges.

The relative behavior of these costs during the new product launch is summarized in Figure 3.

![Figure 3: Behavior of transportation cost drivers during new product launch activities at CPGCo](image)

**The Cost-To-Serve Analysis**

Our analysis showed that it would be misleading to study the change in total transportation costs during supply chain complexity events at the factory level only. Each factory level event affects the transportation costs of the entire network.
To correct for this we conducted a cost-to-serve analysis for each customer. This incorporated the “cost-per-case” to serve this customer. The cost-per-case for each customer had two components: the cost-to-serve this customer (in dollars per case) from the factory that traditionally served this customer and the cost-to-serve the customer from a factory backfilling for the factory that traditionally served this customer. This cost-to-serve was compared for each customer during events and non-events.

This analysis was used to identify and compare the primary backfill factory to any particular customer with the lowest cost option factory within the network. We found that the lowest cost factory was not always chosen to serve a customer during new product launch events. In one event, the primary backfill factory cost 2.0$/case to serve a customer, when there was a lower cost option of 1.7$/case within the distribution network, leaving the primary backfill factory responsible for 23% of supply while the lower cost option was allocated only 4% of supply.

One reason for this could be the short notice given to the transportation planning team during new product launch events. As a result, they may not be able to build enough capacity on the required lanes.

Another reason for this could be a system-wide cost optimization process that weighs other constraints, such as manufacturing and warehousing costs, more strongly.

We extended our analysis to study the behavior of total system transportation costs during high and low season. “High season” refers to a period of peak shipments at each factory (usually 6 to 13 weeks). We observed that during high season, the total system transportation cost variability was on average 20% and that during low season this average variability reduced to 10%. Overall, supply chain complexity appears to cause larger variations during high season than during low season.

**Conclusion**

The key observations from our research are as follows:

1. The relative impact of transportation cost drivers during supply chain complexity events changes depending on the type of complexity event. During new product launch events where a backfill strategy is employed, the major driver of total transportation cost is the average length of haul. This arises primarily because launch factories bear the burden of supplying the entire distribution network with new products and non-launch factories may be required to support the entire network with mature products.

2. Increases in rates (cost per load) are driven by shifts in the carrier mix rather than actual rate increases by each carrier. Routing guide enforcement may ensure rate stability with carriers but not on specific origin-destination pairs. The main reason for this is load rejection and routing guide depth.

3. Supply chain complexity events do not affect the transportation costs only at the launch factory but also the costs of other factories in the distribution network. This is especially prominent in launch factories which rely heavily on backfill factories during non-events.

4. The impact of system-wide transportation costs can be analyzed on the basis of the cost-to-serve a customer within the distribution network. They can be used to develop a simple priority allocation matrix to improve transport planning decisions, especially during supply chain complexity events.