Effects of Truckload Freight Assignment Methods on Carrier Capacity and Pricing

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Abstract

The analysis is based on one year of transactional data from a major beverage company and interviews with asset based and non-asset based truckload carriers. Throughout our research we investigate the use of asset based carriers and brokers as unique sources of capacity on low volume and medium haul lanes. We examine price escalation issues in the context of load tender rejections and daily shipment volumes on a given lane. Our study revealed that as the shipment volume goes up on a lane, prices could escalate as much as 30-40% over rates originally contracted with primary carriers. In the case of rejections though, as prices go up, the probability of not covering a load comes down. Additionally, we propose a lane aggregation methodology, which decreases variability and simplifies freight procurement for long and short haul shipments. Finally, through a carrier proximity study we demonstrate that distance from carrier domicile to pick up location has an impact on pricing for short haul shipments. Based on our findings, we identified building network robustness and creating available carrier capacity as critical factors to sustainable pricing, while still being able to maintain a high service level.

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- Lukasz

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Table of Contents

Table of Figures

Table of Tables

1. Introduction

Transportation is the movement of goods between supply chain parties. According to Standard and Poor (2012), transportation spend in the United States was $694 billion in 2010. Of this, $255 billion was spent on for-hire truckload (TL). Our study focuses solely on the for-hire TL industry where a truck moves one shipment directly from origin to destination.

Managing and executing transportation procurement effectively is a key element of being competitive in today's business environment from the strategic and operational point of views. It is critical to make sure that there is a sufficient number of trucks to move one's freight at a predictable price while demand for TL freight is expected to grow at 2.5% per year (S&P, 2012). Securing carriers can be difficult in a time when fluctuating fuel prices squeeze available capacity and the government is shortening hours of service and tightening driver's safety requirements (ATA, 2011).

Shippers want to have carriers that can offer high quality service at a reasonable price and carriers want consistent freight that fits within their network and increases their asset utilization. It is important that there is a strong relationship between the carrier and shipper. If the shipper tries to negotiate the carriers down on price they may find it hard to secure high quality carriers that will meet their level of service. To ensure available capacity of high quality carriers, a strategy must be created during procurement and a relationship must exist where each party benefits from being a part of the other's network.

The objective of our research is to determine which factors have the biggest impact on carrier capacity creation and how each of those elements affects the price paid for moving freight. Our study looks into the network of one of the largest beverage producers in the United States, Large Co. To see how things work in practice, we highlight key insights based on our recent work with Large Co. and interviews with their carriers and brokers.

1.1 Truckload Industry

The US trucking industry is composed of around 45,000 companies ranging from $3 billion in revenue, such as JB Hunt, to less than $1 million in revenue for over 30,000 companies (S&P 2012). The main actors involved in the transactions are shippers, who own the freight, and asset based carriers, who are physically going to move it. In certain situations intermediaries known as brokers or non-asset based carriers, are involved. These parties facilitate the transactions between the shippers and carriers by connecting the two for a fee. Shippers evaluate their carriers and brokers on speed, service, flexibility, costs, and area served (S&P, 2012). The firms that continually excel in these categories will continue to attract shippers.

For carriers, gaining efficiency is accomplished by balancing their network and increasing the number of loaded miles driven. Every time a truck arrives at a destination, the carrier is facing a "backhaul problem". Demirel et al. (2007) describe it as a "situation where the volume of transported goods or persons is not in balance between two (or more) locations" (549). However, understanding how the imbalance affects the pricing on individual carrier level is very difficult. The current studies only focus on more aggregate levels such as regional or national. As a result of imbalances in the flows of transportation, the price on a headhaul is going to depend on how much money the carrier is going to get on a backhaul. On lanes with high demand for a specific type of equipment at origin and low demand at the destination, the backhaul price falls down to zero, according to Demirel. This means that in such situations it is the headhaul shipper who is going to cover the full price of a round-trip (Demirel, 2007). In some cases the shipper fits within the carrier's network as a backhaul. In these instances the carrier is most likely able to offer the best price because it costs them the least to service the shipment since they are already traveling in that direction.

Every shipment is a new transaction that needs to be facilitated. The scope of the transaction includes finding a carrier that meets a shipper's criteria and one that is willing to move freight at a price both parties find acceptable. Matching of shippers and carriers usually happens in two ways: forward contracts and use of the spot market. Forward contracts allow shippers to negotiate the terms with carriers for a specific period of time. Spot markets allow shippers to look for carriers when they are unable to cover a shipment under the existing contracts, need additional capacity, or try to benchmark their pricing.

1.2 Procurement Methods and Transportation Contracts

Most shippers buy transportation services using forward contracts by collecting bids and allocating them to specific carriers far in advance. It allows them to preselect the carriers they want to do business with, formalize details of their relationship regarding rates and level of service as well as make the future tendering process more efficient. From the shipper's perspective, price is usually the most important factor when deciding on business awards. However, as Sheffi (2004, p.248) notes, other factors such as on-time performance, available equipment type, familiarity with existing operations, and ease of doing business together have a significant impact on the total value of services provided by a carrier.

In order to design a strategy for the bidding process, shippers must first understand their network and determine lanes and demand patterns. The most widely used type of bidding is called "simple lane bid" (Caplice and Sheffi, 2006, p.43). Shippers look at their historical data and compose a set of one-way lanes with specific volumes and required service levels. Then, they decide who should be invited to the bid based on previously established criteria that include, but are not limited to, incumbency, history track record, network robustness, financial condition, and technological capabilities. Once invited to the auction, carriers bid on single origin-destination (OD) lanes. Sometimes volume constraints can be added which allows the shipper to limit the number of winners on a specific lane. Usually the bidding process only lasts for about one or two rounds, but sometimes more rounds are conducted. After bidding is complete, the shipper awards volume to each carrier based on their optimization framework, which includes price and other critical performance factors (Sheffi, 2004, p.250).

Another type of bid process is a combinatorial auction. It is similar to the regular bid process, except that multiple lanes are awarded to carriers in a package (Caplice and Sheffi, 2006). These lanes are most likely located near each other and can decrease the rate per lane based on economies of scale and scope. Although overall combinatorial auctions do offer benefits, they are not always used because shippers may not have matching volume to keep their network balanced.. Also, parties involved in the bid process often do not have the required technology or data to conduct such a bid effectively.

Caplice (2007) writes that it is important to plan strategically through the procurement process by selecting the right carriers to optimize the shipper's network. The selected carriers are added to the electronic catalog to be used in operations. Highest priority carriers are considered "primary carriers" and rank first in the routing guide. Rank is determined by how well the carrier performed in the Winner Determination Problem (WDP). The WDP is an optimization model based on the previous requirements determined by the shipper, such as price, capacity, or service region.

To implement the strategy, when tendering loads, shippers go through the routing guide and tender shipments to carriers according to their rank. If primary carriers are not available, shippers will continue moving down the routing guide until a suitable alternate carrier is selected (Caplice, 2007). If no carrier is found in the routing guide, shippers will then resort to the spot market. Public exchanges exist where the carrier can load its lanes and rates to be paired with potential carriers or be contacted by carriers who are interested in the lane. The first carrier to respond that meets the specifications wins. As in the bid process, the carrier is selected on specific attributes determined by the shipper – in the reverse auction process, usually price.

Contracts are often complicated and require significant effort of time and energy to negotiate, so using them with every transaction is not very effective. Masten (2006) states that contracts are best used for "intertemporal bundling," or bundling transactions over a period of time. For example, a shipper can sign a general service contract with a carrier and every time a new lane comes up, all that needs to be agreed upon is the price. This contract decreases the hold-up that would have been created by having to negotiate the lane hundreds of times over the year.

Another downside of transportation contracts is that they are non-binding, despite there being an implied obligation (Caplice 2007). Masten (2006) explains that since trucking contracts are non-binding, relationships are often hurt or even broken when expectations are not met. Although no penalty is built into the contract, shippers can penalize the carriers by taking away their business and awarding it to a competitor.

In the end, it is in the best interest of a shipper to ensure that selected carriers can execute on their commitments and meet expectations. Otherwise, the lowest rate will stay as such only in theory, while in practice, the shipper will need to source transportation from another provider. As Caplice and Sheffi (2006) point out, "if the new business does not really fit the winner's network, the service will likely be poor regardless of contract terms or past performance" (32). Besides the already mentioned factors that directly impact the transportation procurement, Caplice and Sheffi also address systemic issues of robustness and simplicity. Since the demand on specific lanes does not always follow the original forecast, primary carriers that were awarded the business need to be able to accommodate increased volumes of shipments. If they are unable to do so, the backup carriers should be able to cover short-term fluctuations or become active in case a primary carrier goes out of business. Handling robustness is not easy to incorporate into the bidding process, thus shippers end up relying on backup carriers willing to cover at higher cost.

Understanding the contract framework is critical when attempting to recognize the different needs of players in shipper-carrier relationships. Strategic procurement planning translated into operations leads to an efficient network for all parties involved. In our case, while working with Large Co. and trying to optimize available capacity, we needed to keep in mind that proposed solutions will only be effective if carriers have an incentive to live up to the contracts they sign.

1.3 Paper Organization

In our paper we begin by discussing previous studies and findings on carrier allocation and capacity management. Next, we highlight the methods we used and steps we took to organize and prepare the data. Then, we outline the results and key findings from our data analysis.

Finally, we provide recommendations on what actions we believe should be taken to increase available carrier capacity and decrease transportation costs. The project is closed by a brief summary of our findings, key takeaways, and recommendations for future research.

2. Literature Review

In order to better understand aspects related to truckload capacity and pricing we reviewed existing research and reached out to industry experts. Even though no significant research has been done on managing truckload capacity, previous studies have addressed the different levers used to manage pricing and have provided an overview of the transportation industry.

This section presents the economics and motivations of parties involved in the shipping process. It explains the role of carriers and intermediaries in capacity creation, markets for transportation, and the dynamics governing them. Additionally, we also describe strategic and tactical procurement methods which are used to maximize carrier service level while keeping prices of freight under control.

While describing a broad range of ideas, the goal of this literature review is to familiarize the reader with concepts we will be using in the following sections.

2.1 Importance of Carrier Economics

Carrier economics play a large role in shipper and carrier relations. As discussed in Collins and Quinlan (2010) and Caplice and Sheffi (2003), economies of scale are used to spread costs over multiple units to lower unit costs. However, in the TL industry, economies of scale do not apply. Adding more volume to a specific carrier does not always translate into a lower price. In reality, it may ultimately cause prices to go up due to the reallocation of the carrier's assets and the potential deadhead miles.

In a cost-plus business, both parties are aware of the providers' costs and profit margins (Caplice Class Notes, 2012). Cost structure can easily be calculated by the shipper as it applies to carriers across the board. Moreover, since the trucking industry is so fragmented, fierce competition between thousands of small companies limits the upside with constant revenue pressures and tight margins. Carriers can stay competitive and still make money if they can operate efficiently through high equipment utilization and low number of empty miles.

Hence, in the case of TL, focus needs to be on economies of scope. Unlike economies of scale, economies of scope decrease transportation costs when shippers allocate a specific set of volume to a carrier that fits within its network. In an optimized network, the number of empty or "deadhead" miles decreases and carriers do not have to spend money to reposition equipment (Caplice and Sheffi, 2003). As a result, they can share the benefits with shippers by offering lower rates.

While discussing economics of carrier operations, it is important to explain what generally goes into the cost of a direct TL shipment (Caplice Class Notes, 2012):

$$\text{Shipment Cost} = \text{Linehaul} + \text{Loading} + \text{Unloading}$$

Loading consists of placing the product on a truck and securing it for shipping, while unloading is taking the product off the truck and delivering it to the customer. Linehaul is a function of the total distance and rate for a specific shipment. According to Chainalytics (Caplice Class Notes 2012), distance determines about 70-80% of the transportation costs for a carrier. The rest is accounted for by multiple factors, among which are regional impacts, freight balances, and network efficiency or handling times.

When planning for procurement, it is important to understand the needs and costs of carriers to help optimize their network and lower transportation costs. Just giving carriers more volume is not going to lower the price. However, giving carriers the right volume that fits within their network will be beneficial for both parties.

2.2 Bidding Uncertainty as a Factor in Carrier Bid Behavior

The aforementioned research addresses the impact of economic activity as a factor in the efficiency of lane aggregation. Caplice and Sheffi (2003) explain in more detail how systemic uncertainty affects carriers' response to forward pricing commitments. Shippers allocate the lanes and hold the carrier to contracted rates for the duration of a bid. As a result, carriers tend to bid higher on lanes to offset the risk of economic factors and network complexity.

The authors discuss three major problems related to traditional bidding of lanes: incentive compatibility, interdependency issues, and system constraints. Incentive compatibility occurs when carriers do not bid their lowest price and hedge knowing the freight will be allocated to the lowest bidder from the pool of responders. Interdependency issues occur since carriers operate based on the economies of scope, rather than scale. Allocating lanes individually in most cases does not create an efficient combination for the carrier, even though it may result in the lowest price for the shipper. System constraints are caused by the inability of a shipper to look at more than one lane at a time, which prevents optimal allocation of lanes for the pool of carriers.

Other sources of uncertainty while conducting bids are related to quality of information and network imbalance. Not having enough information can result in carriers either bidding too low and not being able to service the lanes, or bidding too high and not being awarded the business. Network imbalance, on the other hand, is related to economies of scope, where a carrier is "awarded lanes that complement each other during the bid and then being tendered loads on these lanes during daily execution" (Caplice and Sheffi, 115).

Caplice and Sheffi (114) also address the phenomena of the “winner’s course,” which was first introduced by Capen, Clapp and Campbell (1971). During competitive bidding when key information remains uncertain, the bidders, in our case the carriers, end up in a disadvantaged position. The less information carriers have, the lower they tend to bid in order to acquire the business. This situation is magnified by the fact that, unlike with oil plot purchases, described by Capen, Clapp and Cambell, where the investments are final, carriers do not have an obligation to execute on their commitment. As a result, if more carriers are not performing as expected, the bid process needs to be repeated to remedy the situation or shippers go to the spot market.

2.3 Creation and Role of Spot Market

In the transportation markets, when carriers participate in a series of auctions and build their networks, there is always some slack capacity resulting from the fact that the nodes of different shipments do not always come close to each other. After completion of a load, carriers need to reposition their equipment to be ready and able to serve another customer they made commitments to. In such situations, a carrier’s goal is to deliver the originally contracted shipments at the lowest possible cost (Garrido, 2007 p.1069). As a result, carriers are willing to sell the slack capacity below market price or even at the marginal service cost, just so one can service originally contracted lanes and reduce operating costs.

An alternative method to long-term contracts is purchasing freight in the spot market through electronic exchanges or by dealing with agents that have access to larger carrier networks. As Garrido (2007) points out, transportation contracts are established for long-term periods ranging between one to two years. On one hand, long-term contracts provide stability of pricing, but on the other hand, eliminate flexibility resulting from new carriers coming into the markets, new technology, or sudden economic changes. However, the price of flexibility is the variability of rates, which fluctuate together with the market conditions. Despite the uncertainty, even shippers that generally use long-term contracts, in some situations, need to resort to the spot markets if they need additional capacity on temporary basis. The spot market also opens a set of possibilities to shippers where they can always complement their long-term bids and gain additional level of flexibility.

2.4 Role of Market Depth and Business Relationships

Hubbard (2001) notes that the larger the number of potential carriers available to a shipper, the more likely the shipper is going to use the spot market – directly contracting with the carriers or through intermediaries. This stems from the fact that a larger pool will lead to more competition, and thus lower prices in the spot market. Conversely, if a carrier pool is not thick, then contract rates will provide a lower price because of the limited competition and capacity in the spot market. This effect is amplified when dealing with long haul shipments, because the higher paying loads attract carriers from farther away.

Hubbard (2001) also discusses the relationships between carriers and shippers. Carriers want to partner and build relationships with shippers that have steady flows of volume and low variability, while shippers want carriers that are cost effective, meet their needs, and are operationally flexible. These relationships seem easy to understand on the surface, but are actually quite complicated because of the difficulty of aligning the needs of all parties involved.

To enhance relationships and offer better prices, carriers can position their equipment near the shipper and create drop-and-hook programs. Drop-and-hook occurs when a carrier utilizes its fleet to create a pool of equipment located at or near a shipper's facility. Trailers are pre-loaded and placed at the facility to be picked up by a driver. When a driver arrives he or she will drop off their current empty trailer and immediately hook up to the full trailer. The time saved of not waiting to load the truck greatly increases utilization of a driver's hours, which is very important, especially with the Department of Transportation regulations limiting hours of service (Ervin, 2012). With mutual understanding, such investment by the carrier in the shipper can benefit both parties.

It is important for shippers and their trading partners to have transparent relationships. If a customer demands an agile and responsive network, it is crucial for the shipper to find carriers that can meet the expectations (Hubbard 373). It is also important for the customer to realize that the extra flexibility their network requires will lead to higher costs for the carrier. These higher costs will directly impact the shipper's profits and eventually will translate into higher prices for the customers. If all parties involved understand this concept, it is much easier for customers and shippers to share risks and develop efficient networks.

It is very important to understand the dynamics behind behavior of each party involved in the supply chain. Based on the nature of the relationships between shippers and carriers, it is in the best interest of the shipper to make sure carriers have enough incentive to perform. Otherwise the shipper will be the one paying higher price in the spot market or by using backup carriers.

2.5 Role of Brokers in the Industry

In the for-hire carrier market, brokers serve as intermediaries connecting shippers and carrier in the marketplace. They compete with other brokers and are an alternative to dealing with asset-based carriers. Asset-based carriers own the physical equipment they use to move freight for their customers. Brokers, also known as non-asset based carriers, do not own any of the equipment used to service their customers. The value of a broker is that they facilitate the transaction between shippers and carriers, connecting the two for a fee by bridging an operational or information gap (Broker 1 Interview, 2012).

Brokers can best serve the low-volume and highly variable lanes, because asset-based carriers do not want to commit their equipment to loads that are not consistent and may not ship for days at a time. Unfortunately, brokers are somewhat limited. Because brokers do not own the fleet, they are not able to create drop-and-hook programs with their customers (Broker 2 Interview, 2012) or service short haul lanes very well. For an asset-based carrier, their base of operations is most likely located near the shipper and limits the total distance traveled, resulting in a lower price. For a broker, it is not economical to service short haul lanes, since they need to deadhead the carrier from further away than a local company would when they bring a truck. Also, the nominal profit margins on low value shipments do not always justify the effort from the broker (Broker 1 Interview, 2012).

2.6 Freight Volume Balancing and Backhauls

The inbound to outbound ratio of shipments for a specific shipper or region has significant implications on how shippers manage their transportation, their relationships with carriers, and how much they pay for freight. For example, if a shipper has procurement lanes with volumes of raw materials similar to those on outbound lanes, it will have a balanced inbound to outbound ratio. These procurement lanes can be bundled with the outbound lanes to be used as backhauls for the carrier to decrease shipping rates. Hubbard (2001 372) explains:

> "Route-specific investments can enable carriers to obtain better matches to their outbound hauls and thereby lower the effective cost of outbound hauls. For example,

> carriers can utilize capacity at a higher rate when they can identify shippers that frequently ship goods in the opposite direction and coordinate schedules."

The use of backhauls saves carriers time and money, which in turn lowers the rate for shippers. If a specific lane has a destination that has few shipments coming out and the shipper does not offer a backhaul, then the carrier will charge a price premium to cover the round-trip or deadhead costs (Armstrong 2009).

While speaking with a transportation manager from Large Co. Beverage, he explained to us how the company benefits from an imbalanced network. The manager noted that the company has over 95% of outbound freight. Large Co. positions its plants in regions that have a low outbound and high inbound number of shipments, such as Florida. This benefits the company in two ways: first, it is much easier to find carriers, and second, it lowers the company's shipping rates.

Inbound to outbound ratios are very relevant to our study. Understanding the backhaul and freight imbalance phenomena is very important from the tactical point of view when procuring freight and even more critical from the strategic perspective when setting up network or locating distribution facilities. The majority of Large Co.'s lanes are outbound, so it is important for us to understand "lane balancing" while making our recommendations on their future strategy and operations.

2.7 Benefits of Lane Aggregation

Collins and Quinlan (2010) discuss lane aggregation as a method to optimize shipping cost and carrier performance. They conclude that aggregation of low volume lanes can generate savings. However, the cost benefit depends on the size of region at origin and destination being aggregated (Collins and Quinlan 2010). Caplice and Sheffi (2006, p.28) describe, the lanes are not always specifically on a point-to-point basis. A lot of times shippers aggregate their demand anywhere from a five digit zip region to a three digit zip region, state to state, or a combination of any of the regions mentioned. The benefits of lane aggregation are twofold. Aggregation allows for presenting more stable demand to the carriers and a lower number of lanes to be managed in operations. Yet, the larger the area defined as origin or destination, the more uncertainty the carrier has asserting the amount of deadhead miles to their next load. The derived savings of aggregation come from avoiding the spot market with low volume lanes. Collins and Quinlan's (2010) study reveals that aggregation of low volume lanes generates around 7% cost savings, depending on the shipment activity in a specific area.

Furthermore, the research indicates that shippers wanting to aggregate lanes should explore the lanes' historical records to find opportunities for aggregation. Data used in the study indicated that 27% of the spot loads occurred on the lanes where freight had moved within the past year. Doing the analysis of spot bids will reduce the number of spot lanes over the long-term.

Even though the study is comprehensive and addresses core factors related to lane aggregation, it only focuses on long haul shipments (over 250 miles) and discusses excess capacity issues in light of the economic decline in 2009. Although the economic downturn raised carriers' willingness to accept lower paying contract loads, thus increasing the effectiveness of lane aggregation, the core principles described in the paper are still applicable to our research.

2.8 Conclusion

Although no single source has focused primarily on increasing capacity utilization, we found many insights throughout the process that we will be able to use as a foundation for our research.

Furthermore, the literature review gives us a deeper understanding of the truckload industry, carrier-shipper relations, and strategic perspective on freight procurement.

3. Methodology and Data Description

This section will describe sources of information, methods, and tools we used to analyze data collected in our research process

3.1 Process Evaluation Model

Throughout our data analysis we guided our research based on a hierarchical pyramid model we designed specifically for Large Co. (Figure 3-1). It provides a top-down approach to evaluating metrics and trends in transportation for the company. It is very important to have a consistent view across the entire network and always be able to drill down through each level. Looking at all the metrics through the lens of time allows to see trends and changes happening in the system. This approach allows for pinpointing potential issues in the system and helps to design responses to improve performance.

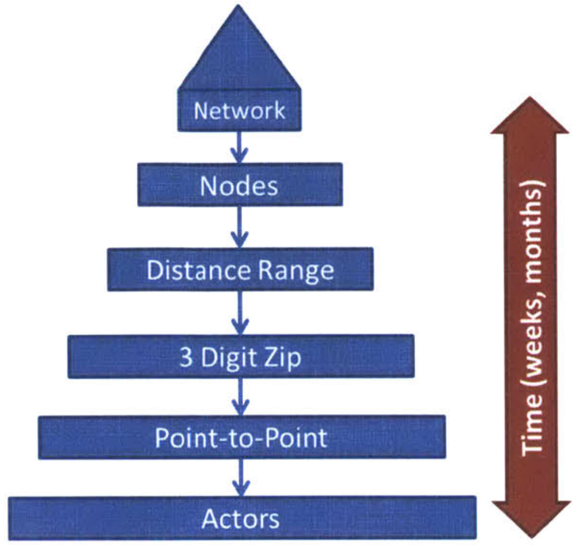


Figure 3-1 Company Analysis Framework

The top block indicates the view on the entire network. Nodes relate to specific shipping facilities. Distance range divides shipments into segments based on the number of miles and underlying carrier economics. Three digit zip zones allow for independent geographical aggregation of volumes. Point-to-point designates location specific lanes and actors include all the relevant parties involved, such as carriers, brokers, customers, and departments.

3.2 Sources of Data

Our sponsor company provided historical shipment transactional data. Also, we conducted interviews with Large Co.'s carriers and brokers to better understand existing processes.

3.2.1 Electronic Data Description

Data relevant in our studies included:

- Transactional data (origin, destination, shipment data, linehaul cost, distance, carrier) – period from October 2010 through September 2011.

- Shipment tender data (all tender lines including accepted and rejected information) – period from January through September 2011

- Spot market data (spot requests with carrier responses) – period from March through September 2011

Different data ranges for each data set were determined by the implementations of specific functionalities in the Transportation Management System (TMS) operated by Large Co. Even though the data sets did not fully overlap, the data samples were representative and sufficient to conduct intended analysis. Overall, the data we received from the company were consistent and of high quality. It allowed us to conduct the analysis without the need for a significant cleanup.

3.2.2 Data Organization and Structuring

In order to be able to utilize the data more efficiently, we segmented the information in the following ways:

- Distance Bracket – we broke down the data into segments of 0-10, 10-50, 50-100, 100-180, 180-280, 280-400, 400-500 and 500+ miles. The first range was selected on the basis of carrier economics and the remaining distance brackets were created based on drop in average price per mile. First, we calculated average rate per mile in 10 mile intervals, then starting from 10 miles up, we used a 25% drop in rate per mile to establish boundaries for each category. Since the trend of falling prices flattens out around 500 miles, we stopped our segmentation at there and included all long haul shipments in the 500+ miles group.

- Carrier Classification – we worked with Large Co. to determine what role each carrier serves the company. In situations where carriers use a mix of assets and brokerage, we looked at how the majority of the volume was handled and assigned categories accordingly.

- Shipment Sequencing - organizes shipments in order the tenders were accepted by carriers. We sequenced the shipments on a basis of three digit zip lanes. Shipments were organized by lane, ship date, tender acceptance time, and linehaul. Shipments are tendered over the course of multiple days to ship on a given date. Using tender date shows how primary carrier capacity gets depleted and when different sources of capacity get engaged.

- Shipment Ranking – organizes shipments based on the price paid. We ordered shipments ascending by price and ranked them on a basis of 3 digit zips for a given day.

On top of the segmentation we also wanted to narrow down the data in terms of freight origin locations. We selected the top 6 sites for our analysis. They accounted for 86% of transactions in Large Co.'s network.

3.2.3 Interviews

Since our study focused on the for-hire trucking industry, we had to understand the views of the multiple parties involved. Throughout our research many questions developed for Large Co. and its trading partners. To gain additional insights we conducted interviews with Large Co.'s carriers and brokers.

We chose to use standardized open-ended interviews. This type of interview allows for open discussions yet is highly focused (Patton 346). It is standardized because most questions are the same for each interview, however, as the conversation develops, we can build on gathered information, which leads to new insights. The ability to compare answers is very helpful to our research because it allows us to see the differences among Large Co.'s various facilities and carrier profiles. The open-ended nature of the interview led to discussions that furthered our understanding of each interviewee's operations, their relationship with Large Co., and their perspective on what works well and what does not.

3.2.3.1 Interview Question Structure

Based on our analysis, we created profiles for carriers and brokers that we felt could best answer our questions and give us the best view of Large Co.'s network and relationships. Our criteria considered:

- Asset-Based vs. Non-Asset Based
- Large Co. Facility Served
- Type of Service: Short vs. Long-haul

We chose to interview asset-based carriers and brokers because we felt it was important to see each of their perspectives and what their goal is when working with Large Co. Specific production facilities and different lengths of haul were selected because we wanted to compare the different challenges and opportunities for each. We worked with Large Co. to specifically identify carriers that would fit our profiles. Going through Large Co. to help us facilitate telephone interviews was critical, as they owned the relationships with the carriers. To conduct the interviews, we created a set of standardized open-ended interview questions that consisted of:

- Experience and Behavior Questions
- Opinion and Value Questions
- Knowledge Questions
- Background/Demographic Questions
- Truly Open-Ended Questions

Experience and Behavior Questions were used to get a feel for what a typical day is like working in the trucking industry, and specifically, working with Large Co. It also gave us information about carrier's background and insights into different strategies of company. Opinion and Value Questions helped us determine what each specific carrier and broker valued the most in their operations. For example, many asset-based carriers valued consistent volume and how much money they can make per truck per day, while brokers put more emphasis on how they can fit into Large Co.'s network. Knowledge Questions were used to determine what the respondent actually knew about Large Co.'s operations and how their networks interacted on a day-to-day basis. Background/Demographic Questions gave us a picture of our respondent's history and experience in the trucking industry, working with their firm, and working with Large Co. (Patton 348-351). Finally, Truly Open-Ended Questions were used to hear from Large Co.'s partners on what they believe can be improved and what other suggestions they may have. This type of question allowed the responders to "speak in their own words" and stay away from fixed responses (Patton 353). These responses gave us a better idea of how the carriers and brokers feel towards working with Large Co.

Three non-asset based carriers, two brokers, and one asset/non-asset based carrier were interviewed. Interviews were done by phone and structured to take about a half hour to an hour, depending on depth of the conversations. According to Rubin (2004), the interviewer determines depth; if we feel we need more clarification we may ask "why" and go deeper, or we can continue on with the interview, as we were pleased with the initial response. Answers were transcribed onto paper and later typed for our notes to help guide us in our data analysis. On one occasion, a follow-up telephone interview was conducted to further clarify one of our findings brought on by the initial interview.

3.3 Tools

Since the data sets we gathered contained hundreds of thousands of records, we utilized MS Access and MS SQL 2008 to conduct the analysis. Our original data came in Excel and csv files, after uploading it into the databases, we established proper indexes on each table for query performance purposes.

For demand mapping we used software as a service solution provided by batchgeo.com.

We utilized Google Maps to geocode zip code locations and get straight line distances between points. Also, we developed a simple mapping tool based on Google Maps, so we could mark circles of a given distance around specific locations.

We used Excel's multiple regression tool to determine how much of our dependent variable, linehaul, can be described by our independent variables, total empty miles and distance from shipping facility to destination. The relationship is determined by looking at the adjusted R^2, or the percent of variability that is explained by our independent variables (Bertsimas and Freund, 2004).

3.4 Summary

In our research we used quantitative and qualitative data elements to analyze transportation assignment implications in the network of our sponsor company. Data for our study came in the forms of physical information extracted from the Large Co.'s systems and in the form of interviews we conducted with Large Co. and its providers. Gathering the information and finding the right tools was a lengthy process, however, having everything organized and ready in advance allowed us to efficiently conduct our data analysis.

4. Data Analysis and Findings

Throughout this section, using sponsor company data and other sources, we explore answers to the underlying question of this thesis. Our analysis consists of two major sections. While the first portion provides an overview of the sponsor company network, the second focuses on presenting key outcomes we gathered throughout the course of our research. Even though the analysis is based on the model of Large Co.'s network and processes, the intent of the study is to provide insights that could be applied across the industry. The analysis can serve as a framework for approaching similar problems in different business settings.

4.1 Network Overview

This section provides general information about Large Co.'s network and serves as an introduction to overall analysis.

4.1.1 Shipment Distribution by Length of Haul by Facility

Although Large Co.'s facilities produce the same type of product across all of their plants, transportation networks for each facility have very different characteristics. Looking at all shipping locations together provides us with a broad picture accounting for length of haul, geographical factors, and demand patterns. As an example, Figure 4-1 illustrates differences between the number of shipments for specific distance brackets for each location.

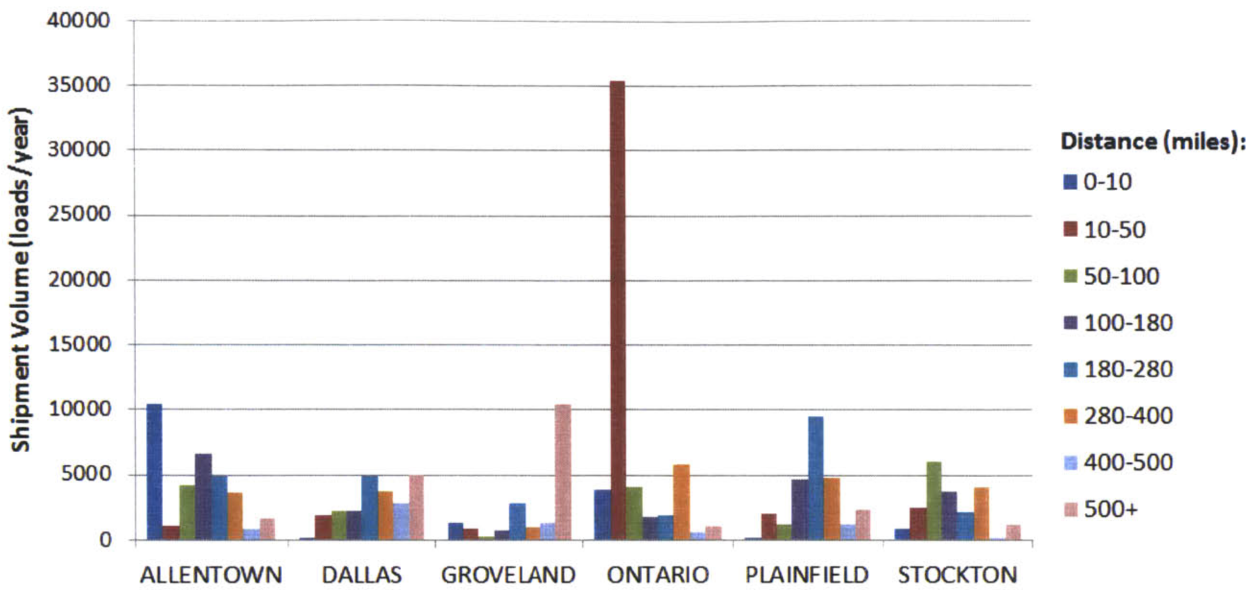


Figure 4-1 Shipment Volume Distribution by Location and Distance Bracket

Ontario, Calif. has the largest number of shipments in the 10-50 miles radius. Customers served from this facility are located in close proximity to the production plant and the distribution area is densely populated. On the other hand, Groveland, Fla. has a lot of freight that goes over 500 miles. Inexpensive backhaul rates are the main reason behind such a long haul distance enabling Large Co. to serve customers in far away markets. Florida has large freight imbalances and carriers are willing to offer lower prices to take them to where the freight is. In the case of Plainfield, Ind, the distribution center is located around 200 miles from major metropolitan areas such as Chicago, Ill., Louiville, Ky., St. Louis, Mo., and Cincinnati, Oh. These three facilities are just an example of how diverse transportation networks can be. Companies need to understand those differences in order to manage their transportation effectively.

4.1.2 Demand Patterns

Large Co. is a fast growing company. When looking at the demand pattern, we can see that volume is not only trending positively, but also seasonally. The peak time comes in the summer with the slowest time in the winter. Figure 4-2 illustrates the growing trend and reflects seasonality.

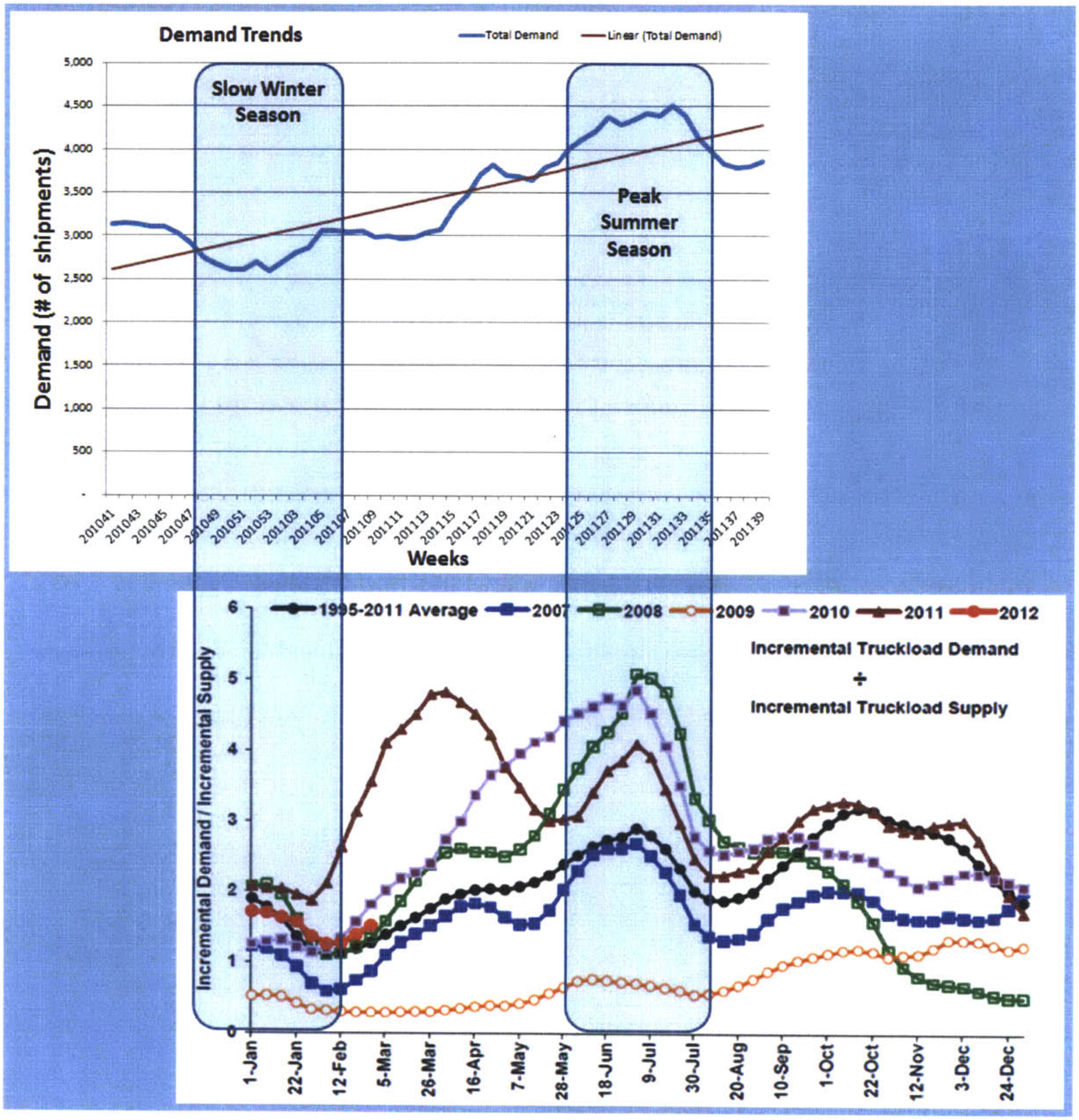


Figure 4-2 Large Co.'s Van Freight Demand vs. Market Demand for Van Transportation

In our study, we wanted to see how the seasonal factors are related to general market demand. Our analysis shows that in the case of Large Co., the seasonality patterns overlap with each other, as illustrated by the Morgan Stanley Truckload Index and Large Co.'s demand chart. The relationship of these two patterns has great business implications for Large Co. The company has an abundance of trucks available during a slow time and it needs to compete with everyone else for scarce capacity when the demand for their products is high.

4.2 Sources of Capacity

In this section we will discuss the sources of capacity in the marketplace. Additionally, we will also present how Large Co. uses each one of them in their transportation sourcing process.

4.2.1 Use of Asset Based Carriers and Non-Asset Based Carriers (Brokers)

Companies can access carriers either by directly dealing with them or through intermediaries. Since there are over 40,000 trucking companies in the US, it would be almost impossible to try to reach out to every carrier. Likewise, it is not a core competence of Large Co. to manage a large pool of carriers. Therefore, when Large Co. contracts freight it tries to secure primary capacity with asset based carriers and keep brokers as a backup.

Using intermediaries gives the shipper access to the spot market without directly participating in it. Brokers maintain relationships with multiple carriers, make sure they have proper insurance, and adhere to safety standards. In most cases they also keep track of carrier performance across many shippers. As a result, brokers can almost always deliver available capacity provided the right price, as our interviews with truckload brokers confirmed.

Carriers do not strictly fall into the categories of those that own and do not own the assets. Some companies that own trucks, for example, also have a brokerage arm. During our interviews with a major US truckload carrier, the company explained their business model, in which they utilize their own assets for long haul shipments and use brokerage for medium and short haul moves.

Moreover, the ability to broker loads gives them additional flexibility. In situations where they have commitments to clients and do not have available capacity, they can always contract another carrier regardless of the length of haul and serve their customer.

Since often it is difficult to classify a company specifically as a carrier, a broker or a mix of thereof, in our analysis, when we categorized the carriers, we worked with Large Co. to determine which carrier falls into each category. In cases where carriers mix their assets with brokerage, we looked at what specifically is used to haul Large Co.'s freight and how the majority of the freight is hauled. When the majority of the volume was moved with owned assets, we classified a carrier as asset-based. The same rule applied for designating a carrier as a broker.

Our analysis shows that 76% of transactions are handled by carriers and 24% by brokers. Additionally, we looked at the amount of money spent on linehaul within each category. This gave us 62% of spend being allocated to carriers and 38% to brokers. Length of haul for each category is the reason why the numbers are significantly different from each other. A long haul shipment, even though there are fewer of them, can account for cost of multiple short haul moves.

We also looked at each location to see how each uses carriers and brokers. Table 4-1 shows the allocation by each shipping location. As we showed in the previous section (4.1.1), the length of haul structure is different for each location, so is the broker utilization by each site as well.

Table 4-1 Broker Utilization by Location

	ALLENTOWN	DALLAS	GROVELAND	ONTARIO	PLAINFIELD	STOCKTON
% of shipments - broker	21%	42%	16%	16%	26%	39%
% of $ spent - broker	30%	53%	23%	42%	34%	49%
ALOH - carrier	149	257	440	56	237	162
ALOH - broker	258	481	595	321	271	230

ALOH - Average Length of Haul (miles)

4.2.2 Use of Brokers Depending on the Length of Haul

Use of brokers versus asset-based carriers also varies significantly by distance as shown in Figure 4-3.

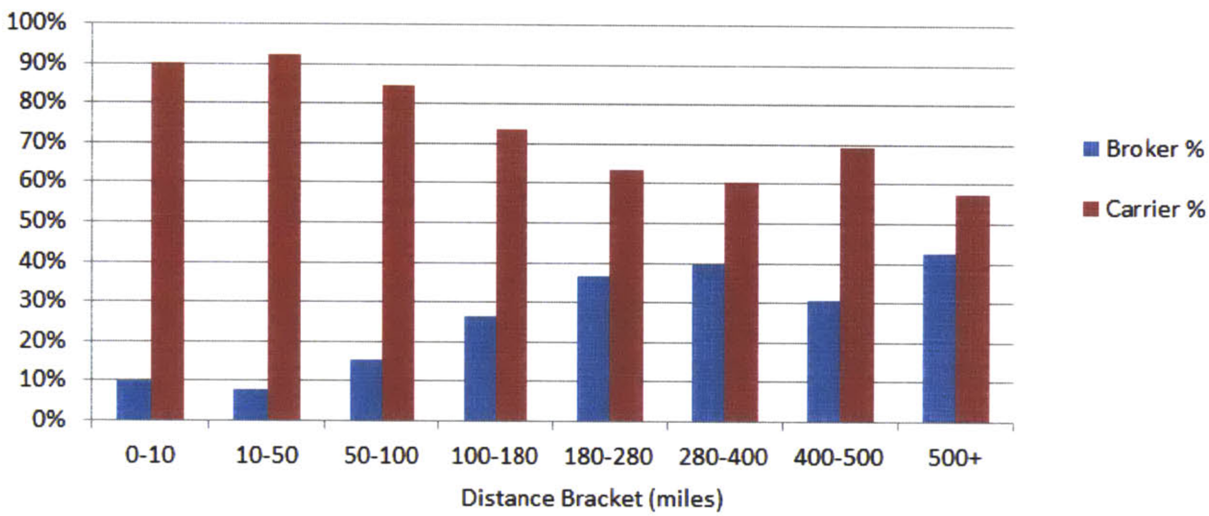


Figure 4-3 Broker vs. Carrier Utilization by Specific Distance Brackets

The longer the distance, the higher the utilization of brokers. During our interviews with carriers and brokers we identified the following factors as key drivers of this phenomenon:

- Up to 100-120 miles, asset-based carriers can do multiple trips a day dedicating assets to one shipper, even if they have to come back empty.

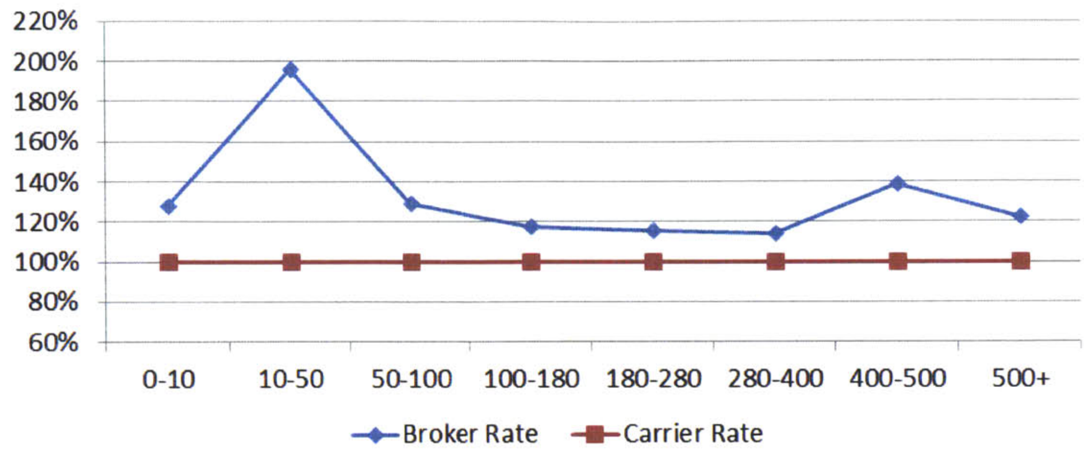
- Above 150, miles it is not economical for carriers to come back empty and they are less willing to take a load knowing that the probability of finding a load back is low or it may take a long time. This provides an opportunity for brokers that can offer competitive rates on a one-way basis.

- The nominal profit a broker can make is significantly lower on short haul shipments: 20% on $500 is $100, while 20% on $300 is only $60.

- Sourcing of short haul freight due to its higher volumes and predictability is relationship based, where local carriers work closely with the shipper. Local carriers with equipment in close proximity have an advantage hauling this type of freight, as it fits best in their network.

- The pool of carriers willing to go for a long haul trip in a specific location is limited. Therefore, brokers have the advantage of accessing temporary capacity.

The dynamics in carrier economics are also reflected in the difference between the average rate per mile paid to the carrier versus broker in a specific distance bracket. Figure 4-4 shows that in the range of 10 to 50 miles, rates with brokers are almost twice the average price with carriers. However, the difference drops to as low as 14-15% for the range between 180 and 400 miles.



Distance	0-10	10-50	50-100	100-180	180-280	280-400	400-500	500+
Broker/Carrier	128%	196%	129%	118%	115%	114%	139%	123%

Figure 4-4 Broker Price Premium by Distance Bracket (Broker Rate/Carrier Rate)

The difference in price can be attributed to two main factors:

- The type of lanes brokers cover
- The point in the tendering process when brokers engage their capacity

If brokers do not get business on regular basis and are only called in situations when local carriers run out of capacity, the brokers need to bring carriers from further away, which in turn raises the prices. If brokers could expect a steady flow of business, they could make sure they have a pool of capacity available to serve Large Co. To support the claim we can analyze longer haul lanes where brokers are selected as primary carriers. Given steady business, they are able to compete with asset-based carriers and offer reliable service levels. We can also see it reflected in the decreased difference in price between carriers and brokers on shipments over 100 miles.

In the two following sections will provide a more in-depth look at the role of brokers for Large Co..

4.2.3 Use of Brokers Depending on Freight Volume per Lane

To better understand the use of intermediaries, we investigated how the usage of brokers varies depending on the amount of freight per lane. In our interviews with asset carriers, one topic that came up was a difficulty in handling Large Co.'s freight on new and very low volume lanes. In contrast, when we talked to brokers, they saw the type of freight as an opportunity. They understood well where they provide value to the shipper, and if freight does not get tendered to the carriers, they will be able to provide ad hoc availability.

Table 4-2 illustrates use of brokers depending on the shipment frequency on specific lanes. Each distance bracket is considered individually and colors emphasize combinations of distance and volume where broker utilization is the highest. Shades of green and yellow indicate low use of brokers, while red and orange point out high utilization. The analysis focuses on distances of 100 miles and over, since utilization of brokers in those ranges is significant compared to shorter ranges. For this analysis we defined lanes as origin zip to 3 digit zip destination zone, and we used the amount of money spent with brokers versus carriers to calculate the percentages.

Table 4-2 Broker Utilization Based on Shipment Frequency per Lane

Annual Volume	Distance bracket				
	100-180	180-280	280-400	400-500	500+
<20	57%	58%	47%	40%	35%
20-50	27%	25%	27%	32%	40%
50-100	12%	16%	26%	19%	43%
150-100	7%	45%	54%	21%	37%
150-250	19%	27%	39%	28%	33%
250-500	15%	28%	33%	18%	25%
500-1000	47%	31%	37%	30%	49%
1000+	28%	46%	51%	64%	65%

When looking at each distance bracket individually in Table 4-2, we can see that brokers are the most often used on low volume lanes with less than 20 shipments per year. Broker usage increases again on high volume lanes with more than 1,000 shipments per year. These insights align with the information we received from the interviews with the carriers and brokers, where both expressed a preference for a specific kind of freight and were confirmed by a X^2 anlaysis. The X^2 told us with 95% certainty that this data was not random and is a true representation of the network. Based on the results, we can conclude that brokers can deliver extra capacity in ad hoc situations as well as offer additional bandwidth when volumes are high and local carrier base is not sufficient enough to fill existing demand.

4.2.3.1 Carriers vs. Brokers in the Tendering Process

To find out where brokers come in the process of tendering shipments, we looked at the top 41 high level lanes, ranging from 10 miles upwards. As in the previous analysis, we defined lanes as a combination of origin and 3 digit zip destination zones. Then, as described in section 3.2.2, we organized shipments in a sequence they were tendered for a specific day. We considered lanes over 100 miles, as use of brokers on lanes below 50 miles is low due to carrier economics (Table 4-3). The study revealed, that the use of brokers on all lanes over 100 miles went up from 31% to 45% at sequence number 10 and finally 66% at sequence number 23 (Figure 4-5).

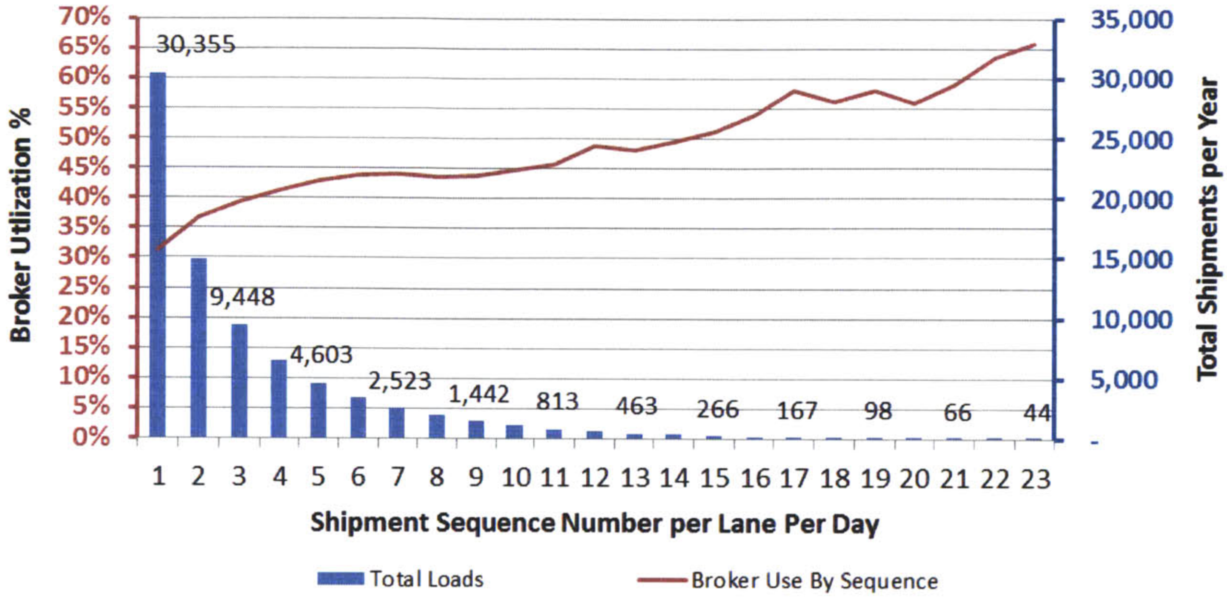


Figure 4-5 Broker Utilization Percentage by Sequence Number over 100 Miles

We also investigated how brokerage use varies over a range of distances (Table 4-3). As the table indicates, use of brokers intensifies in the range of 100-500 miles and goes up in the higher sequence numbers. Yet, it comes down on lanes over 500 miles. During our conversations with carriers we learned that asset based carriers are not willing to go over 120-140 miles if they do not have a freight to come back. It gives an opportunity for brokers that can send carriers one way. Brokers can also deliver capacity at shorter notice than asset based carriers, which is why they are utilized more often late in the tendering process.

Table 4-3 Broker Utilization by Distance Bracket and Daily Sequence

	Distance Bracket						
Sequence No	**10-50**	**50-100**	**100-180**	**180-280**	**280-400**	**400-500**	**500+**
1	13%	15%	20%	29%	38%	30%	37%
2	12%	15%	26%	36%	42%	35%	42%
3	10%	17%	29%	39%	41%	38%	46%
4	11%	17%	31%	43%	40%	40%	50%
5	10%	16%	34%	45%	41%	45%	49%
6	11%	18%	36%	47%	42%	48%	49%
7	11%	21%	36%	46%	42%	51%	49%
8	10%	19%	37%	46%	40%	61%	46%
9	9%	19%	39%	44%	42%	59%	48%
10	9%	16%	44%	45%	42%	61%	44%
11	7%	13%	45%	48%	47%	46%	42%
12	7%	15%	47%	51%	56%	29%	41%
13	6%	17%	45%	48%	62%	45%	39%
14		13%	41%	49%	64%	33%	45%
15		6%	35%	54%	67%	57%	38%
16		15%	39%	50%	76%	83%	
17		13%	48%	60%	77%		
18		11%	44%	53%	75%		
19		5%	54%	41%	78%		
20		6%	43%	45%	74%		
21				52%	68%		
22				73%	67%		
23				79%	67%		

Lanes over 500 miles are equally attractive to brokers and carriers as they generate much more revenue and usually entail a multiday trip. When we looked into lanes and transaction specific data, it turned out that a lot of lanes are contracted 100% to brokers or asset carries. The remainder can either be tendered 100% to carriers or split between asset and non-asset based carriers. To test if this data was a true represnetation of Large Co.'s network we ran a X^2 analysis. We concluded with 95% certainty that this data was not a random sample. Because of the higher attractiveness of the long haul lanes to asset based carriers they are more willing to compete for shipments in this bracket rather than short haul or short lead time loads.

4.2.3.2 Summary

As we showed in this analysis, understanding different sources of capacity in the market is very important. Without steady and scheduled volumes it is difficult to fit directly into a network of an asset based carrier. On the other hand, for shippers to participate in the spot market directly means deviating from their core competence. Freight brokers, though, are already active in the spot market and dealing with them gives shippers indirect access to thousands of carriers through one point of contact. Shippers gain extra flexibility and can be sure they will have available capacity. However, since brokers have a wider reach, they may need to bring capacity from farther away and charge a fee for their service, which in turn translates into a higher price.

4.3 Shipment Rejection Analysis

While shippers would like to tender a load to a carrier at a previously negotiated price and have it picked up, it does not always work that way. If the economics are not favorable or the load does not fit into a carrier's operations at a specific moment, the carrier may reject the tender and the load will be made available to other providers. In our conversations with carriers and Large Co., the main factors for load rejection were:

- Not enough lead-time to secure a truck
- Surge in volumes on specific lanes
- Shipments on not previously contracted lanes
- Long load times at origin or unload times at destination
- Going to an area of weather impact

- Inconsistent lane activity (happens when same customer is supplied from multiple locations)
- Previously offered rate is too low

Throughout our interviews we learned that as carriers spend more time with Large Co., they get more accustomed to doing business with the company and know what to expect. In some occasions, though, on new lanes with new consignees, the carriers become victims of the "winner's curse" and cannot support the lane as committed. In such situations they either leverage their relationship with Large Co. to adjust the terms or Large Co. assigns another carrier who can provide the required level of service.

Having a strong relationship and good track record helps carriers in the long run when dealing with Large Co. Incumbents get preferential treatment during bid events and by working closely with the company, they get a chance to organize their network around Large Co.'s demand. As a result, they can benefit from economies of scope that benefit both parties.

Even though, in the analyzed nine-month period only 3.6% of Large Co.'s shipments that have been rejected at least once, analyzing this information gives us additional details about what happens when tenders are not accepted and what is driving the rejection behavior. In our study we count loads as rejected only once. So, if a specific load is rejected 10 times, we view it as single rejection with the depth level of 10.

4.3.1 Rejection Analysis by Shipping Facility and Length of Haul

As we previously showed with brokerage use and distance of haul, each shipping site has very different characteristics. The same applies to the rejection frequency, which can range from almost 0% to over 9%, depending on the particular location. Also, the rate of rejection varies by the distance hauled. It is close to zero up to 100 miles, increases in the range of 100-400 miles, and then slightly drops for shipments over 500 miles (Table 4-4).

Table 4-4 Rejection Rate as a Percentage of Total Shipments per Origin and Distance Bracket

Site Location	Site Rejection	0-10	10-50	50-100	100-180	180-280	280-400	400-500	500+	Total Rejected	ALOH (miles)
ALLENTOWN	1.82%	0.00%	0.04%	0.17%	1.02%	0.42%	0.11%	0.04%	0.02%	468	178
DALLAS	6.18%	0.00%	0.43%	0.04%	1.07%	2.58%	1.12%	0.47%	0.46%	1176	272
GROVELAND	7.14%	0.00%	0.37%	0.00%	0.58%	0.23%	0.33%	0.17%	5.46%	1198	542
ONTARIO	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	6	866
PLAINFIELD	9.26%	0.00%	0.29%	0.14%	1.66%	2.57%	2.41%	0.82%	1.38%	2052	310
STOCKTON	0.47%	0.00%	0.00%	0.02%	0.01%	0.05%	0.38%	0.00%	0.01%	76	343
Total Rejection %		0.00%	0.16%	0.06%	0.67%	0.87%	0.64%	0.22%	0.94%	3.6%	
Total Loads Rejected		1	219	86	932	1216	893	310	1319	4976	

In our conversations with carriers we learned, that they would usually round-trip equipment up to 100-140 miles and be willing to come back empty. However, beyond that distance, they would try to look for a backhaul load to still to make a profit. By going up 100-150 miles, carriers can complete around two loads a day, which provides them with optimal use of equipment. Then, past the 400-mile mark, the situation again becomes more favorable to the carriers. The distance is sufficiently long for the carrier to optimize equipment utilization and driver hours. Since a truck is going to travel to its destination for a day or more, carriers have more time to plan for a backhaul load the next day.

The significantly higher number of rejections in Table 4-4 for Groveland, Fla. on shipments above 500 miles can be explained in two ways. First, when the fruit season arrives, capacity is constrained and carriers that bid lower rates for the majority of the year choose to pick the higher paying loads in the peak season. Secondly, as we Table 4-1 shows, the facility has a very large percentage of volume on long haul lanes, so proportionally more loads are being allocated in the 500+ miles category.

4.3.2 Rejection Analysis by Shipping Facility and Month of a Year

To further understand the structure of rejections per facility, we examined how the rejection numbers behaved over time. Our analysis is based only on nine months of data, as it was all the information the company had available at the time. Table 4-5 presents the results.

Table 4-5 Shipment Rejection by Month and by Origin Location

Month	ALLENTOWN	DALLAS	GROVELAND	ONTARIO	PLAINFIELD	STOCKTON
2011-01	0%	0%	0%	0%	0%	0%
2011-02	0%	0%	0%	0%	12%	0%
2011-03	0%	1%	1%	0%	17%	0%
2011-04	0%	1%	3%	0%	1%	0%
2011-05	0%	2%	4%	0%	6%	0%
2011-06	1%	3%	6%	0%	5%	0%
2011-07	4%	12%	16%	0%	13%	0%
2011-08	7%	15%	12%	0%	14%	0%
2011-09	4%	19%	12%	0%	14%	4%
Total Rej	1.82%	6.18%	7.14%	0.02%	9.26%	0.47%

As we can see, rejection rates get higher further in the year. Three factors contributed to the variation:

- Time from bid – Large Co. bids out their transportation early in the year. The further away from the time, the less likely carriers are to honor the rates.

- Changes in network structure – over the course of the year Large Co. adds new lanes and drops others.

- Seasonal and business factors – variability in available capacity due to local economy or business process changes affect carrier economics.

When looking closer at each facility, we can see low rejection rates for Ontario, Stockton and Allentown. The majority of the volume at these facilities is very short haul, which in general has low rejection rates. For the remaining locations, Plainfield, experienced a process change which doubled the loading time for trucks, and carriers were not willing to pick up loads at the price they originally bid. Groveland, on the other hand, experienced seasonal produce demand, which created competition for available capacity. In Dallas, production related issues affected demand patterns and created high spikes and irregularity in the demand going to specific locations on daily basis. Since the demand was very erratic, carriers were not able to maintain sufficient capacity in the area to be able to handle drastic fluctuations in volume.

4.3.3 Rejections by the Day of the Week

We also investigated whether day of a week affects the number of rejections, and if a shipment is rejected, if there is a difference in rejection depth. Table 4-6 shows the results of the analysis. Based on the information provided, even though Sunday and Monday have the highest rejection ratio, rejections for all days of the week stay below 4% and there are no substantial fluctuations. The Average Rejection Depth tells us how many carriers reject the shipment before it is accepted. In this situation, Saturday and Sunday have the highest depth. However, just as in the case of rejection rate, the rejection depth still did not substantially differ from other days of the week.

Table 4-6 Rejection Rates and Depth by Day of the Week

Weekday	Avg Rejection Rate	Avg Rejection Depth
Monday	3.9%	3.40
Tuesday	3.4%	3.13
Wednesday	3.5%	3.09
Thursday	3.4%	3.24
Friday	3.4%	3.32
Saturday	3.6%	3.89
Sunday	3.9%	3.90

4.3.4 Price Escalation and Rejection Depth

When a tender gets rejected by a carrier, it is offered to another carrier, which usually will ask for a higher price to move it. In our analysis, we looked at the entire collection of rejected shipments above 50 miles and compared the price offered to the first carrier to the price at which the shipment was accepted. Figure 4-6 presents the results of our analysis and it explains how the price escalates with the number of rejected tenders.

Rejection Depth	% of Rejections	% Price Escalaction
1	31%	6.2%
2	19%	8.5%
3	10%	14.1%
4	12%	19.4%
5	7%	15.3%
6	6%	21.4%
7	5%	19.2%
8	4%	24.8%
9	2%	24.5%
10	1%	26.1%
11	1%	29.4%
12	1%	25.6%
13	0%	24.4%
14	0%	35.0%
15	0%	44.3%
16	0%	44.5%
17	0%	48.2%

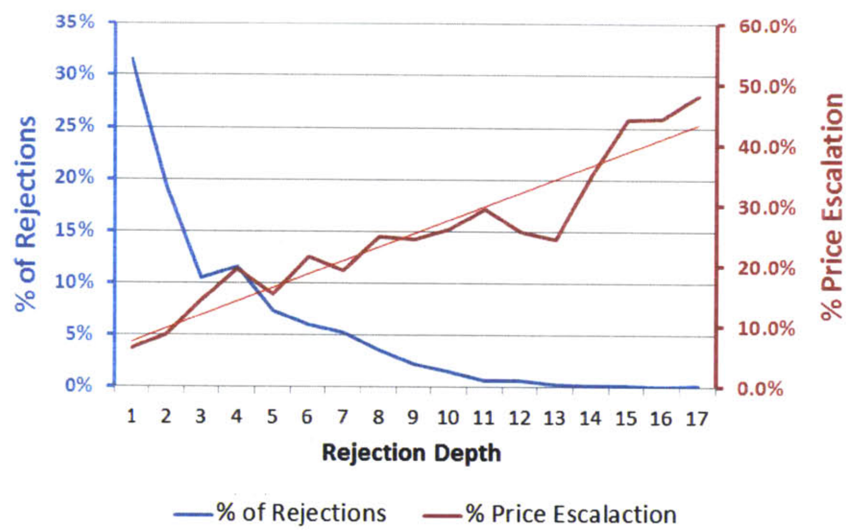


Figure 4-6 Price Escalation per Number of Rejections

Based on the data, just one rejection causes the price to go up on average by 6%, while after the 10^{th} rejection, a shipper should expect to pay 26% premium over what was originally offered to a primary carrier. On average though, for all the shipments that were rejected Large Co. paid 13% more than what had originally been planned.

4.3.5 Shipment Rejection Probability

Another aspect of rejections we considered was the probability of a tender being rejected depending on the sequence number of a shipment on a specific three digit zip lane during the day and in the tendering process. To fully explain the behavior, we added a price escalation factor, which we will focus on in more detail in the next section. As Figure 4-7 shows, the probability of rejections goes up until daily rank of four (as described in section 3.2.2) and then starts dropping down. At the same time, the price keeps climbing up. Probability of rejection based on shipment position in the tendering order behaves almost the same as in the case of daily ranks.

Rank / Sequence No	Probability of Rejection by Rank	Price Escalation by Rank	Probability of Rejection By Sequence
1	3.15%	0%	2.86%
2	4.32%	5%	4.15%
3	4.89%	9%	4.76%
4	5.02%	12%	5.12%
5	4.75%	15%	4.92%
6	4.68%	19%	4.77%
7	4.07%	22%	4.20%
8	4.09%	24%	4.26%
9	3.99%	25%	4.31%
10	3.02%	26%	3.98%
11	2.32%	26%	3.20%
12	2.19%	25%	3.07%
13	2.17%	29%	2.92%
14	2.07%	25%	3.14%
15	1.65%	20%	2.88%

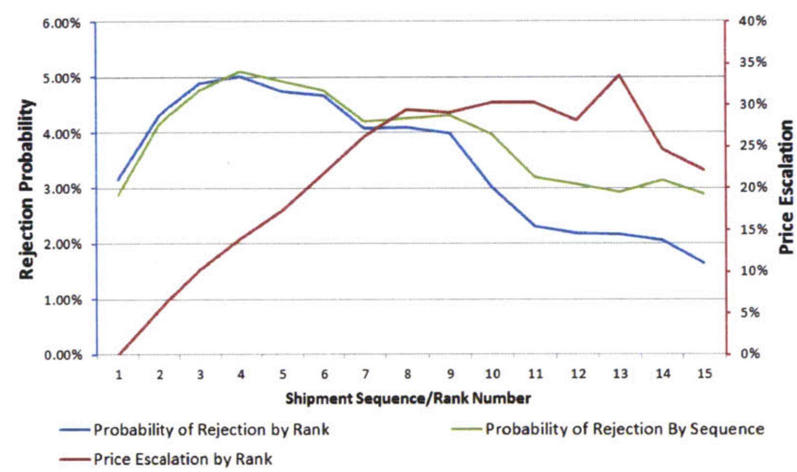


Figure 4-7 Rejection by Sequence/Rank Number and Price Escalation Comparison

When daily shipment ranks are low, the rejection rates are low as well. It can be explained by the fact that shipments are assigned to primary carriers that have performance commitments to the price that they had originally bid. As the sequence numbers (described in section 3.2.2) go up, both price and rejections trend up. This suggests that the likelihood of rejection by primary carriers goes up until the fourth shipment in a row on a specific lane. In the case of daily rank, once it rises above four, the price is attractive enough and more carriers are willing to accept the load; thus the rejection probability starts coming down. With higher pay for the load, carriers are able to bring trucks from farther away as there is enough money to pay for the deadhead miles.

4.3.6 Summary

The study once again emphasized the importance of carrier economics driving performance levels. Understanding the dynamics behind shipment rejection is critical when managing a transportation network. The more tenders are not accepted and the higher the rejection depth, the more the shipper has to pay to move a load. Changes in rejection patterns can help to identify potential problems early in the process so shippers can make adjustments to avoid unnecessary costs.

4.4 Price Sensitivity and Lane Robustness

Network robustness can be characterized by the ability of a system to absorb fluctuations in demand without significant impact on the parties involved. In our study, the relevant parties are carriers and Large Co. as a shipper. The impact could be described as lack of capacity or price escalation when the number of shipments per day on given lane goes up.

In order to test Large Co.'s network robustness, we looked at a combination of the top lanes based on three digit zip origin and destination. For our study, we picked 41 lanes that had daily volume above six. The daily rank numbers, just like those used in previous studies, were based on the number of shipments going to a specific zip zone on a specific day and were ordered in ascending order by price. In addition, we only considered rank number levels that had more than 30 shipments – to ensure that we had a representative sample of data. To calculate the price escalation, we divided average price of higher daily rank numbers by the average lowest price paid on the shipment for the specific lane.

As a result of our study, we determined that in general, the higher the number of shipments on a lane, the higher the average price paid per shipment per each rank. However, not all the lanes responded to volume escalation in the same manner. We attributed this phenomenon to network robustness, which can be measured by the price increase on incremental shipments tendered on the same lane during a given day. On lanes where the network was robust, price escalated slowly and then stayed in the same range, which means that regardless of demand, there was enough capacity to handle the volume at an originally pre-established price. For lanes to be robust, the capacity needs to be available when needed at the shipping origin and carriers need to be willing to go to a specific destination. Figure 4-8 illustrates the difference between more and less robust lanes. Hence, on lanes going to destination zips starting with 853 and 762, the price stayed low and steady, while on lanes 430 and 402, it escalated above the 35% mark.

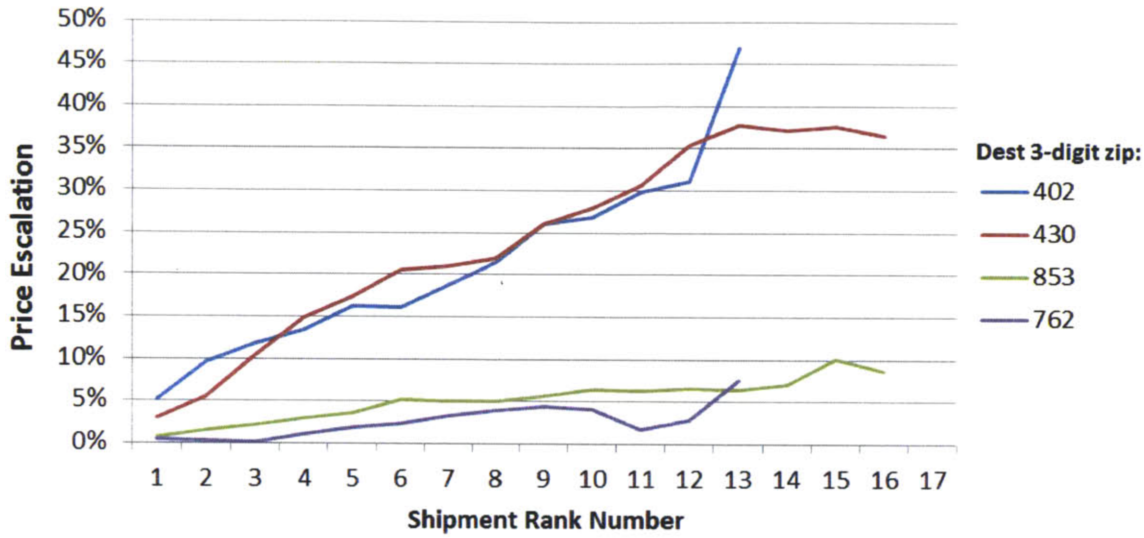


Figure 4-8 Comparison of Price Escalation on Robust and Non-Robust Lanes

We conducted the analysis for all 41 lanes. Since the daily rank numbers of shipments per lane per day were not the same across all origin/destination pairs, we created a metric that would express the additional cost of escalated prices in each distance bracket. Figure 4-9 provides a visual explanation of how the metric is constructed.

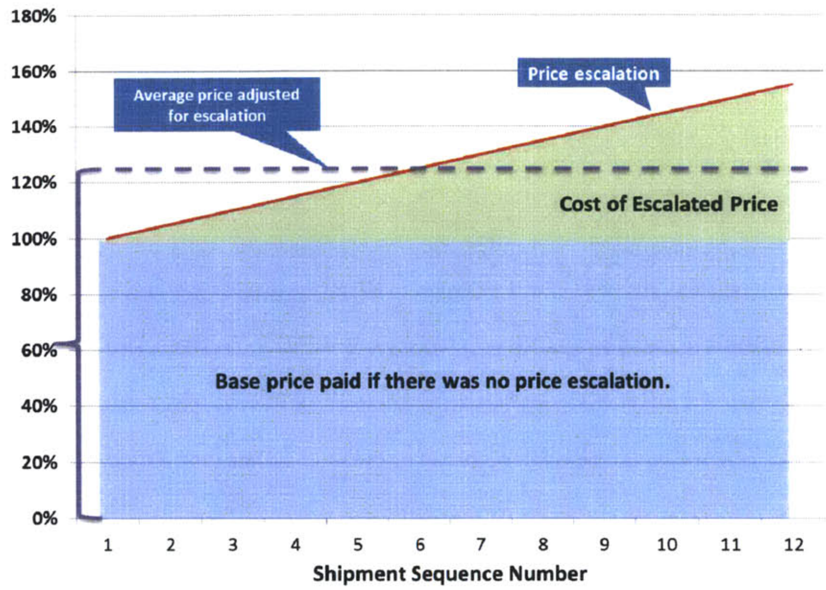


Figure 4-9 Explanation Model of Price Escalation Impact

The blue color represents the amount of money spent if all the shipments moved at the lowest price contracted for the specific lane. The green area displays the additional amount spent as price (red line) escalates with shipment rank number going up. The purple dotted line represents the average price after we spread the escalation premium across all shipments.

The impact of price escalation can also be expressed using an equation:

$$Escalation\ premium = \frac{\sum_{i=1}^{N} \frac{rate_i}{Min[rate]}}{N} - 1$$

Where i refers to the shipment sequence number and N represents the total number of shipments.

As a result of the analysis, we were able to determine how much premium on average is paid per shipment on a specific lane. We summarized the results per distance bracket in Figure 4-10. Even though the initially negotiated price may have been low, the adjusted average prices were from 5% to 17% higher than what was paid on the lowest cost shipments on a given day.

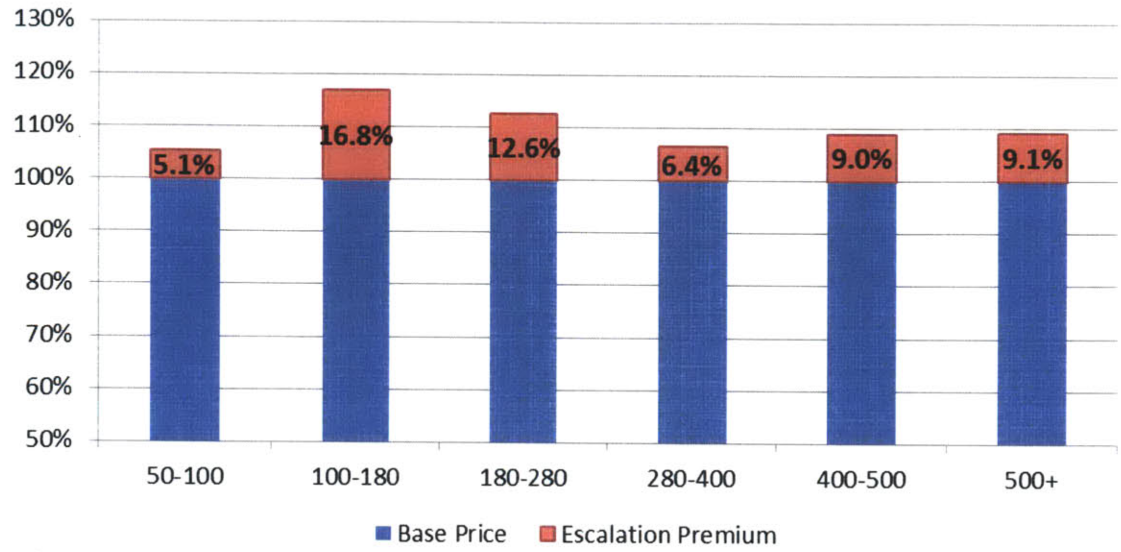


Figure 4-10 Averaged Price Escalation Impact by Distance Bracket

Since the shipper already pays a certain premium on specific lanes and we know, based on Figure 4-8, that the premium cannot be fully eliminated, it poses a question whether we can offer a slightly higher rate to the carriers if they commit to a specific capacity and prevent escalation. The goal should be to drive the premium down and keep it at levels that are necessary to provide the required level of service. Another option would be splitting the difference between shipper and carrier to for the benefit of both parties.

Figure 4-10 shows the premium paid over the average lowest price. Yet, when we compared price escalation on a global level for shipment daily rank and sequence number (as defined in 3.2.2), we learned that in both cases there is inflation and it follows similar pattern.

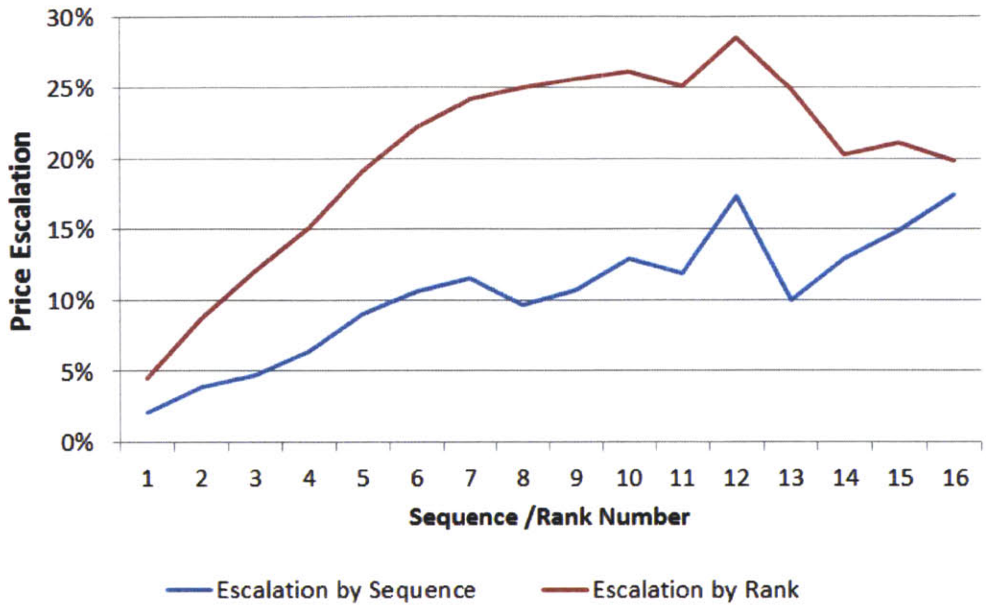


Figure 4-11 Price Escalation Comparison: Shipment vs. Rank

Escalation by sequence number showed lower values because first shipments in the tendering process are not always offered at the lowest price, which has an effect on the baseline price in our calculation. Also, a lot of times in the tendering process shipments can be covered below the original rate, which in turn lowers the average price for higher sequence numbers.

The line for price escalation drops down after shipment rank 12. This is mainly caused by the fact that prices do not escalate equally on each lane and distance bracket. Also, this reflects a varying total number of ranks for each grouping category. If each lane and category were presented separately, then the price escalation would trend up and reflect the rate of price growth for each individual grouping.

4.5 Spot Market Analysis

The spot market is a source of capacity shippers can access when they have new lanes, need additional capacity, or when none of the contracted carriers accepts tenders. Large Co. does not go out to a general spot market. Instead, it facilitates a private exchange among carriers they already do business with to enable spot market requests. Figure 4-12 shows Large Co.'s spot market activity. The majority of the spot requests were for shipments that had no prior contracts in place. Almost 46% of all spot transactions were for situations where Large Co. needed to get capacity beyond what already was contracted. Less than 1% related to all contracted carriers rejecting tenders, which prompted the company to go out with a mass request.

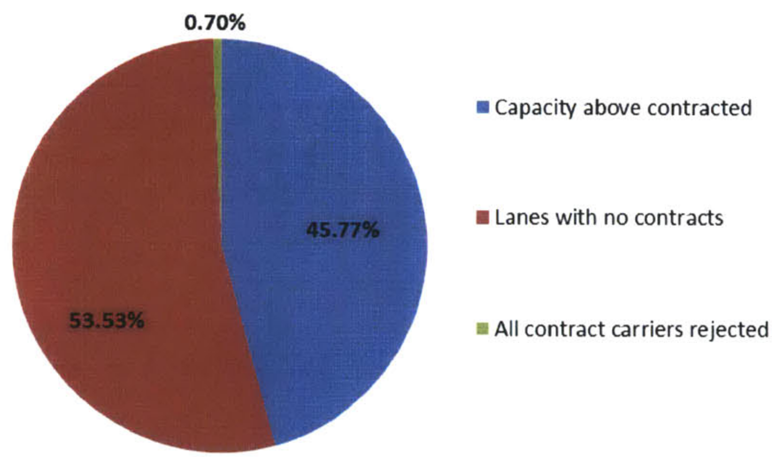


Figure 4-12 Spot Market Activity Segmentation

Instead of trying to go out to the whole population of known carriers, Large Co. accesses the public spot market in two ways: indirectly, through the brokers, in a normal bid process and directly, through their private exchange by reaching out to a specific group of asset and non-asset based carriers they have established relationships with. The size of the direct spot market for Large Co. is only 5.8% of the total number of shipments. However, sending out a mass spot market request, does not guarantee a load will be covered. In some cases, where shipments are not a fit for existing networks, only a few or none of the carriers will put in a bid. Table 4-7 shows the average number of carriers per request and average number of responses.

Table 4-7 Spot Market Activity Statistics

Requests size	Avg # Responses	% of requests	% of no bid
10	1.7	9%	10%
20	2.3	20%	13%
30	2.1	38%	16%
40	2.9	23%	15%
50	3.5	9%	1%
80	3.9	1%	3%

The average number of responses (excluding cases when no carriers bid), is around three per request and a majority of the requests do not exceed 40 carriers. At the same time, the number of requests that get no bids reaches as high as 16%. It is important to notice that when local capacity is depleted, very few carriers are actually willing to bid. However, in most cases, there are always a few carriers that want to take the load to gain incremental business or improve their relationship with the shipper.

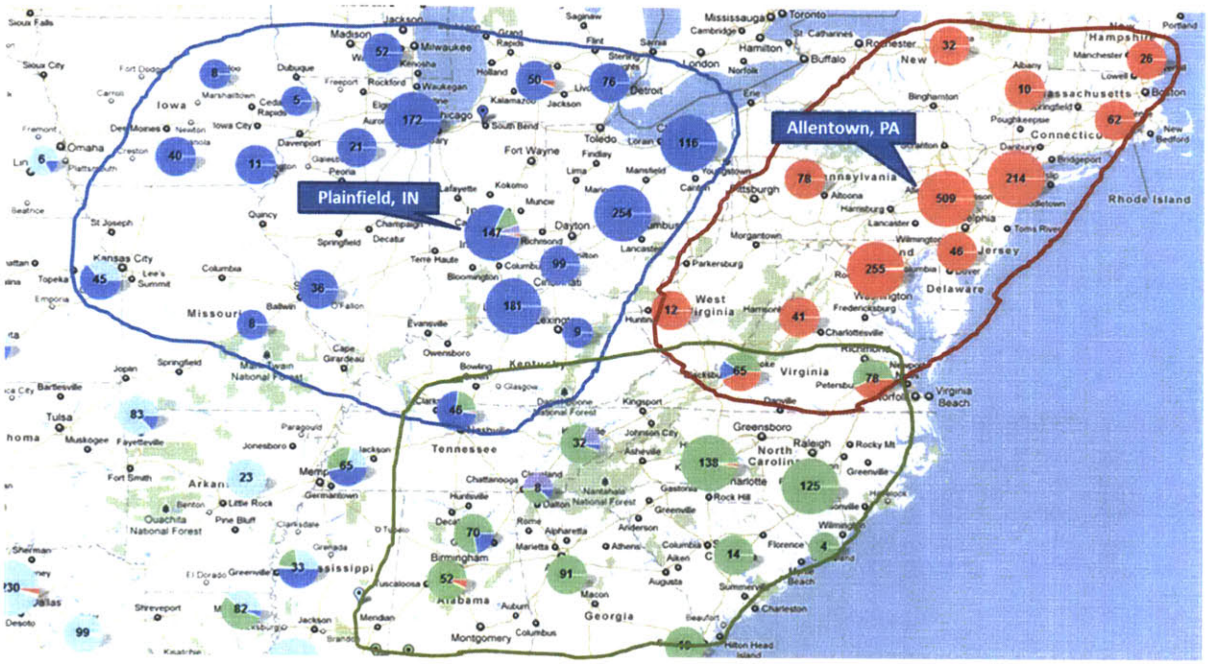
In situations when no carriers bid, Large Co. does a spot market request to the same group of carriers one more time. The carriers seeing the same load again, understand that it did not get covered in the previous round. Hence, they look further for capacity farther away and bid a price at which they can find carriers to move the freight.

4.6 Lane Aggregation Study

Understanding the demand structure is a vital element in determining the design of a transportation network. The key factors include geographical locations, shipment volumes, and demand variability. In the case of Large Co., with a one directional network, the major task is to understand where the customers are located, how much freight is shipped to each location, and how the volumes fluctuate on a weekly, daily, and seasonal basis.

4.6.1 Geographical Demand Overview

To better understand the geographical demand structure, we plotted 2 weeks of demand on a map (Figure 4-13). Each bubble indicates a number of shipments in a specific region. Colors reflect the origin facility of the freight supplying the customers.



Each Circle Represents the Destinations for Freight Originating from:
Red - Allentown, PA | Dark Blue – Plainfield, IN | Green – Groveland, FL

Figure 4-13 Geographical Demand Structure

The map also illustrates how the networks of each facility differ from each other with regards to spatial coverage and concentration of demand. It shows that certain locations can be supplied from as many as three production plants. In the majority of cases, the demand is clustered around metropolitan areas. Due to its complexity and geographical reach, the network presents a number of opportunities to study cost and capacity related subjects.

4.6.2 Cluster Analysis

We investigated two specific clusters of demand for shipments above 150 miles and analyzed demand patterns within 60 miles of a specific shipping facility. Based on the criteria of being supplied by one production plant, having multiple destination points, and being located around major metropolitan areas with high density of demand, we chose to analyze three locations. For the medium haul shipments we selected Columbus, Oh. and the Washington/Baltimore region. For the short haul shipments, we selected Ontario, Calif., which is the facility with the largest concentration of short haul shipments.

4.6.2.1 Long Haul Lane Aggregation and Remote Cluster Analysis

Firstly, we looked into Columbus and the surrounding areas. After plotting the demand on the map, we saw that delivery locations are clustered within a close proximity to the city. Figure 4-14 illustrates the demand pattern in the selected region. A circle with a 20 mile radius was enough to include all the locations in the specific region.

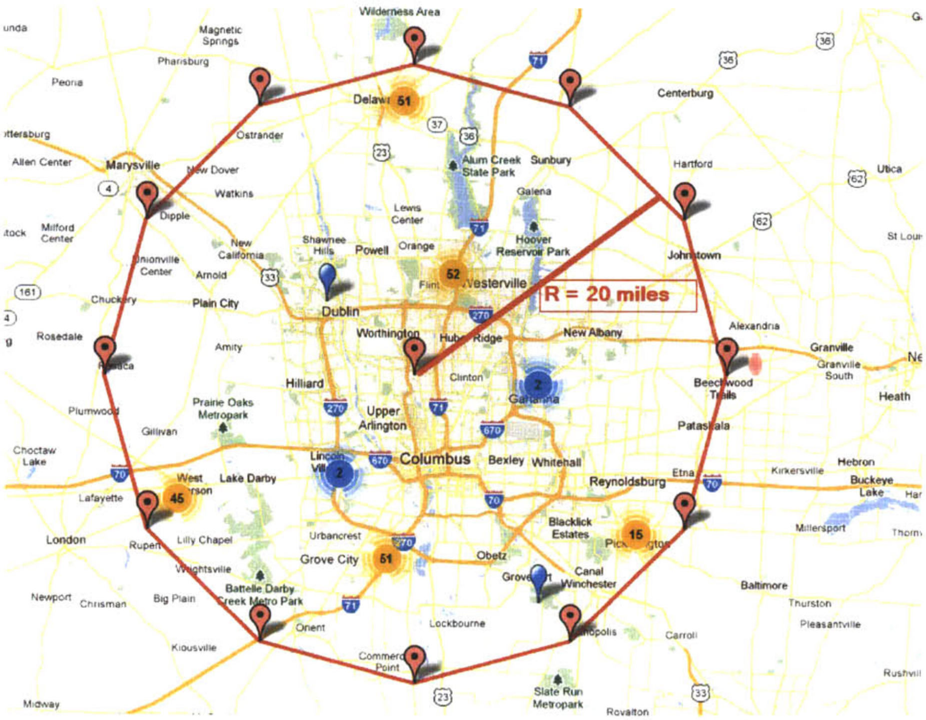


Figure 4-14 Demand Structure in the Columbus, Oh. Area

An examination of the destinations shows, a total of 10 zip codes with two lanes carrying the majority of the volumes, two having 1-2 shipments a week and six lanes with less than 10 shipments per year (Table 4-8). The lanes spanned across three different zip zones.

Table 4-8 Volume Distribution in Columbus, Ohio Region

Zip Code	Zip Zone	Volume
43015	430	3117
43123	431	1270
43240	432	85
43162	431	75
43068	430	9
43130	431	2
43147	431	1
43219	432	1
43228	432	1
43230	432	1

Using the top four lanes we investigated whether combining the lanes would affect variability on a weekly basis. As Table 4-9 shows, that the coefficient of variation for four lanes combined is lower than for each lane individually. Also, the weekly required capacity to cover demand on all four lanes, providing 95% customer service level (CSL), dropped by 11% from 177 to 158 units.

Table 4-9 Lane Aggregation Analysis Columbus, Ohio Region

ZIP	43015	43123	43162	43240	Aggregated
Avg Demand (shipments weekly)	67.8	27.6	1.6	1.7	98.7
StDev	26.2	16.1	4.3	0.7	35.9
Coef of Variation	0.39	0.58	2.65	0.41	0.36
Demand @95% CSL	110.9	54.1	8.7	2.8	157.7
	176.5				157.7

We calculated the number of units of capacity required to provide 95% CSL using the following formula:

Demand @ X% CSL = Mean Demand + (Normal Dist Service Factor(X)*StDev of Demand)

The benefit of aggregating lanes is not very significant on the lane with the highest volume; however, combining all volumes eliminated variability on the remaining three lanes. Thus, pooling risk from multiple lanes provides a more reliable demand forecast that can be presented to the carriers. Although the destination area is much bigger now, with the combined volume of 157 shipments per week, carriers may need to reach out outside of the 20 mile radius circle to find backhauls. Additionally, with different carriers awarded to each individual lane, carriers had to compete for backhauls, while with steady volumes they can develop stable relationships with shippers in the destination area.

Analyzing a cluster around Washington, DC (Figure 4-15), yielded similar results.

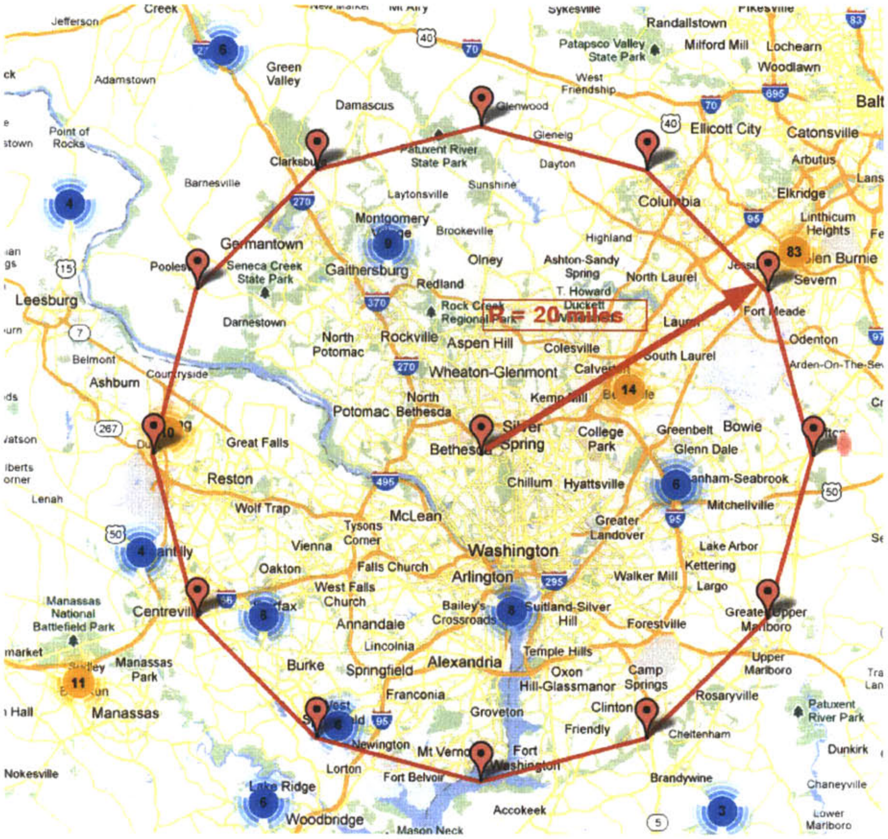


Figure 4-15 Demand Structure in the Washington, DC Area

Here we aggregated volume from the top eight out of 12 lanes (Table 4-10). The aggregation combined volumes for eight different three digit zip zones under one region category.

Table 4-10 Volume Distribution in Washington, DC Region

Zip Code	Zip Zone	Volume
20794	207	1292
20705	207	234
20879	208	176
22202	222	173
20164	201	165
22030	220	140
22153	221	121
20706	207	96
20772	207	2
20785	207	2
20007	200	1
20904	209	1

As Table 4-11 shows, the aggregation resulted in reducing the total required capacity by 13% and decreased the value of the coefficient of variation on the majority of the lanes. It had a particularly high impact on the lane with the highest volume (20,794), where the demand from accompanying lanes smoothed out the total demand for transportation on a weekly basis.

Table 4-11 Lane Aggregation Analysis Washington, DC Region

ZIP	20164	20705	20706	20794	20879	22030	22153	22202	Aggregated
Avg Demand (shipments weekly)	3.2	4.6	1.9	25.3	3.5	2.7	2.4	3.4	47.0
StDev	1.4	1.9	1.1	19.4	1.3	1.1	1.2	1.4	21.3
Coef of Variation	0.44	0.41	0.60	0.77	0.37	0.40	0.49	0.41	0.45
Demand @95% CSL	5.6	7.7	3.7	57.2	5.6	4.6	4.3	5.7	82.1
	94.4								82.05

Aggregation provides improvements in the way demand is smoothed out and presented to the carriers. However, further study measuring the impact on carrier rates and shipment acceptance rates needs to be conducted. To analyze carrier response, a company could bid out destination with heaviest volume and negotiate with carriers what other destinations could be included in the bundle at the same or slightly different price. Another option would be to bid out a few key lanes separately and then calculate a weighted price carriers would agree to for the specific region. Carrier response through rates would determine what is the optimal region size for aggregation and what specific destinations should be included. Volumes would be awarded to each specific carrier after agreement regarding the total aggregation area.

4.6.2.2 Short Haul Lane Aggregation Analysis

After analyzing long haul remote areas of demand, we focused on a short haul region to devise an aggregation methodology for shipments in the close proximity to the shipping facility. For our study we selected the facility in Ontario, Calif. as the number of short haul shipments for the location is close to 95%. However, this time, we based the analysis on carrier economics rather than aggregated demand based on a certain location.

As noted above, carriers revealed in interviews that they were not able to find a backhaul on short haul moves for the majority of shipments, leading them to come back empty to pick up another load. Given these circumstances, distance traveled – not direction – is the relevant variable. Carriers noted that bidding for zones and setting the same pricing in 10 mile increments would be an acceptable way to handle short haul shipments.

Based on information from our discussions with the carriers, we marked zones every 10 miles from the shipping location around Ontario, Calif. (Figure 4-16).

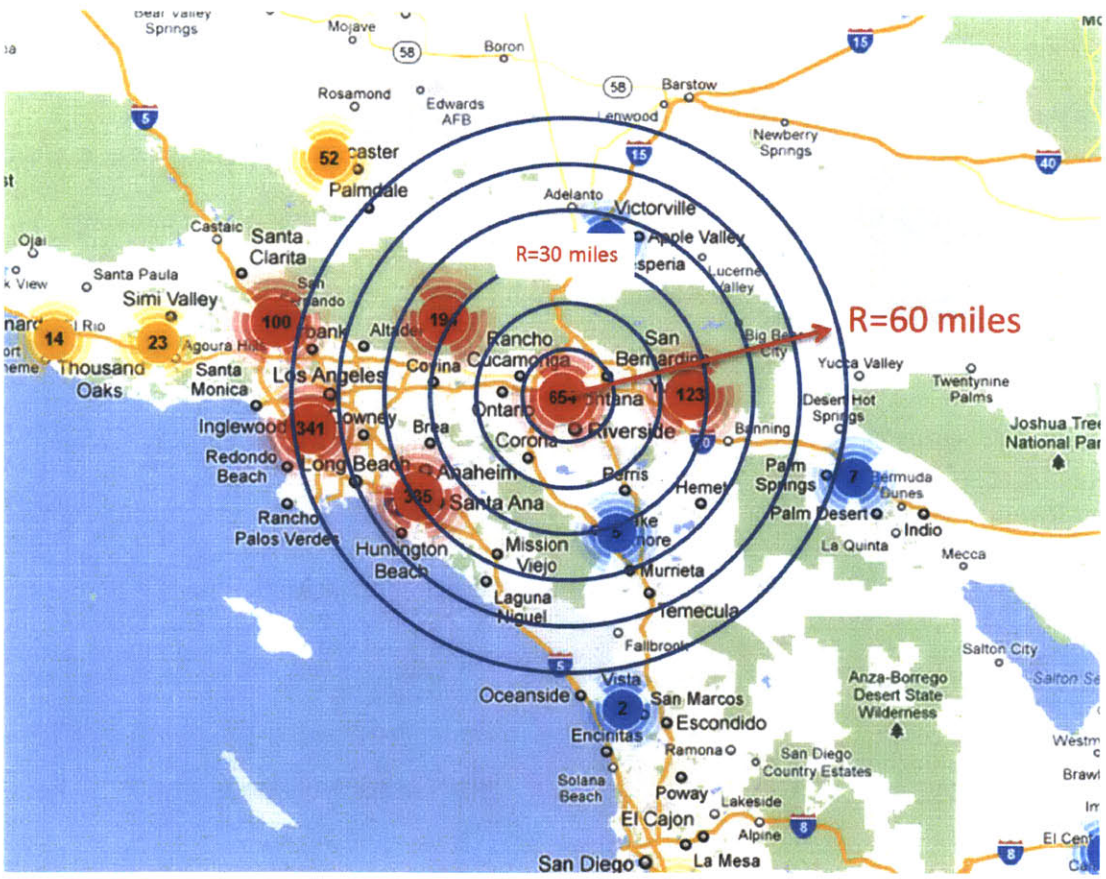


Figure 4-16 Circular Area Selection for Short Haul Shipments

Besides the unified pricing benefit, we wanted see if aggregating lanes in distance ranges of 10 would affect variability. To create a baseline for comparison, we grouped shipments under three digit zip destination zones. This resulted in six categories ranging from 2 to 12 zip zones that combined from 13 to 105 individual zip destinations (Table 4-12).

Table 4-12 Lane Aggregation in 10 Mile Increment Zones

Distance	Unique Zips	3 Zip Zones
0-10	13	2
10-20	23	3
20-30	46	8
30-40	86	10
40-50	105	12
50-60	92	9
Total	365	44

Large Co. originally used around 150 lanes to manage freight in these zones; this model of grouping lanes would cut the number of lanes that need to be managed down to six.

From the capacity perspective, aggregation of lanes reduced by 21% the demand for capacity required to deliver 95% CSL (Table 4-13). Additionally, in every zone, aggregation reduced the coefficient of variation. As a result of the aggregation, Large Co. can give their carriers more accurate information regarding required capacity on a daily, weekly, and seasonal basis. Even though the end location accuracy decreases, with short haul shipments it is not a very important factor because in most cases carriers will come back empty to get another load.

Table 4-13 Impact Summary of Short haul Lane Aggregation

Distance	Demand at @95% CSL		Impact
	Original	Aggregated	
0-10	10,839	9,245	-15%
10-20	28,300	22,235	-21%
20-30	15,254	11,103	-27%
30-40	16,294	13,168	-19%
40-50	7,928	6,867	-13%
50-60	3,250	2,332	-28%

4.6.3 Lane Aggregation Summary

Lane aggregation can help companies pool risk, reduce variability, and decrease the operational complexity of managing transportation. However, the dilemma is always at which level the demand should be aggregated. As we presented in the three studied examples, lanes can be grouped by a specific region, by three digit zip zone, or by a range of distance from a specific point of origin. Aggregating lanes is a strategic task and decisions need to be made prior to bidding out the lanes with carriers. Analyzing and understanding the demand patterns is critical for the process to be successful.

Aggregating lanes needs to be done very carefully and different techniques may need to be used for various destination regions and points of origin. Getting buy-in from the carriers and understanding their willingness to work with aggregated lanes is important. There is a risk that giving carriers less precise information regarding their destinations may increase prices due to a factor of uncertainty. Knowledge of the company's network would favor incumbents who would know where the destinations are concentrated.

Another aspect is the changing dynamics in specific lane packages. When new lanes are added and other lanes drop out, a process would need to be in place to make sure the bundles are updated and required capacity levels are adjusted. However, this element could have a beneficial effect as well. It would provide iterative improvement and fine-tuning within a structure, rather than working with each lane individually.

Finally, the systems used to source transportation and tender shipments need to be capable of implementing chosen grouping methodology.

Even though lane aggregation brings operational benefits for the shipper, the pricing impact and carrier response to the strategy need to be considered before wide implementation.

4.7 Carrier Proximity Study

In the regions where Large Co. has significant volume of short haul shipments, carrier location with relation to the freight destination can have a large impact on a shipper's transportation costs. With increasing fuel costs, every additional mile run by a carrier has a direct impact on its profits. In this study we are going to investigate the impact of carrier location and discuss scenarios to minimize cost implications.

4.7.1 Current Situation

While interviewing one of Large Co.'s carriers, let us call it Fast Trucking (FT), one thing caught our attention: FT serves a large portion of the short haul (less than 150 miles) lanes coming out of Dallas, but is located 37 miles away from the shipping facility. Since these lanes are short haul, travelling the extra distance makes up a large portion of the actual cost of moving the shipment. Since short haul transportation costs make up such a large portion of Large Co.'s annual spend, we wanted to determine how much carrier location affects linehaul rate, how significant the benefits of co-location can be, and what Large Co. can do to mitigate the risk of unnecessary empty miles within its network.

4.7.2 Model Setup

To test this effect, we ran a multiple regression analysis of 3,641 shipments serviced by FT out of Large Co.'s Dallas, Texas. facility. This data included linehaul rate and five-digit zip code of the shipping destination. First, we needed to determine our variables. Since we are looking to see if there is an impact on linehaul, we chose to use it as our independent variable. Next, we created dependent variables. For the purpose of our study we chose to test loaded miles, shipment frequency, and empty miles. Loaded miles is the distance when freight is being moved from Large Co. to the shipping destination. It was calculated using Google Maps by finding the straight-line distance between Large Co.'s facility and the destination zip code. We used straight-line distance for simplicity of calculations. Shipment frequency was found by counting how often a lane shows up in the data. Empty miles were found by combining the initial 37 empty miles and the distance traveled back to carrier domicile from the shipping destination. Then, we ran our regression model to test the dependent variables effect on linehaul.

4.7.3 Regression Analysis

As we were adjusting our model, we found that shipment frequency had an insignificant impact on linehaul and was removed from calculations. Loaded miles and empty miles on the other hand, resulted in an adjusted R^2 of 0.859 and p-values near zero, meaning 85.9% of the variability in the linehaul rate can be explained by these two variables and that the chance of this data set randomly occurring is almost zero (Figure 4-17). According to our regression output, cost per load can be calculated with the equation:

Cost Per Load = 119.77 + (0.39) * Loaded Miles + (2.04) * Empty Miles

This means that it will cost the shipper pays $119.77 plus $0.39 for every loaded mile and $2.04 for every empty mile. Empty miles are much more expensive than loaded miles because while the carrier is driving without freight, they are not utilizing their equipment by wasting fuel and time.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9271
R Square	0.8595
Adjusted R Square	0.8594
Standard Error	21.8395
Observations	3641

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	10611160.94	5305580.472	11123.6642	0
Residual	3638	1735192.778	476.9634		
Total	3640	12346353.72			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	119.7686	2.1745	55.0798	0	115.5053	124.0319
Loaded Miles	0.3951	0.0284	13.9160	6.26242E-43	0.3394	0.4507
Empty Miles	2.0419	0.0350	58.2632	0	1.9732	2.1106

Figure 4-17 Carrier Proximity Study – Initial Regression Output

We then considered the fact that very short lanes can be serviced multiple times in a day by the same truck. Instead of dropping off the shipment and returning back to Rockwall, a driver will return to Large Co., pick up another shipment, and make another short delivery. This process will continue until the driver can no longer operate due to hours of service regulations. To test this, we ran our multiple regression model with different ranges for the distance from Large Co. to its customers. We found that the dependent variables had no significant impact on lanes less than 40 miles (Figure 4-18). The distance from Large Co. to its customer and the total empty miles traveled by the carrier could only explain 15.8% of the linehaul variability. After seeing this result we had an additional interview with FT where they confirmed our hypothesis. Re-running our regression model without lanes less than 40 miles delivered an adjusted R^2 of 0.942 and p-values near zero (Figure 4-19). This regression output gave us a cost per load equation of:

$$\text{Cost Per Load} = 124.31 + (0.91) * \text{Loaded Miles} + (1.64) * \text{Empty Miles}$$

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.4033
R Square	0.1627
Adjusted R Square	0.1581
Standard Error	33.4876
Observations	371

Figure 4-18 Regression Output for Lanes Less than 40 Miles

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9707
R Square	0.9423
Adjusted R Square	0.9423
Standard Error	14.3506
Observations	3270

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	10993327.27	5496663.64	26690.53	0
Residual	3267	672807.88	205.94		
Total	3269	11666135.15			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	124.3126	1.5749	78.9359	0	121.2248	127.4004
Loaded Miles	0.9100	0.0278	32.7025	3.5584E-203	0.8554	0.9646
Empty Miles	1.6432	0.0305	53.8471	0	1.5834	1.7031

Figure 4-19 Regression Output for Lanes Greater than 40 Miles

To further understand the situation, we wanted to determine what proportion of the total distance traveled by FT were actually empty miles. The higher the percent of empty miles, the less money the carrier is making per mile they run, which translates into decreased asset utilization and higher costs to Large Co. According to our regression model, the carrier compensates for this decrease in utilization by incorporating about $1.64 per empty mile on Large Co.'s linehaul rate. Since the shipping destination will never be at Large Co.'s facility, it tells us that there will always be empty miles because the carrier will always have to drive back empty from the shipping destination. The savings are found by limiting these empty miles.

4.7.4 Scenario Analysis

To test the impact of decreasing empty miles we looked at two different scenarios using Large Co.'s facility, a customer, and a carrier. By moving the position of the carrier and comparing it to the empty miles incurred in the current situation we can see the effect carrier location has on empty miles and linehaul cost.

Scenario 1A (Figure 4-20) shows the current network of a customer being serviced in Sanger, Texas by FT out of Rockwall. In this scenario, empty miles (denoted in red) is equal to 87 or about 64% of the total distance traveled. Multiplying the empty miles by the empty miles regression output tells us that Large Co. is currently spending $142.96 on empty miles per shipment to service this customer or about 45.75% of the average linehaul rate on this lane.

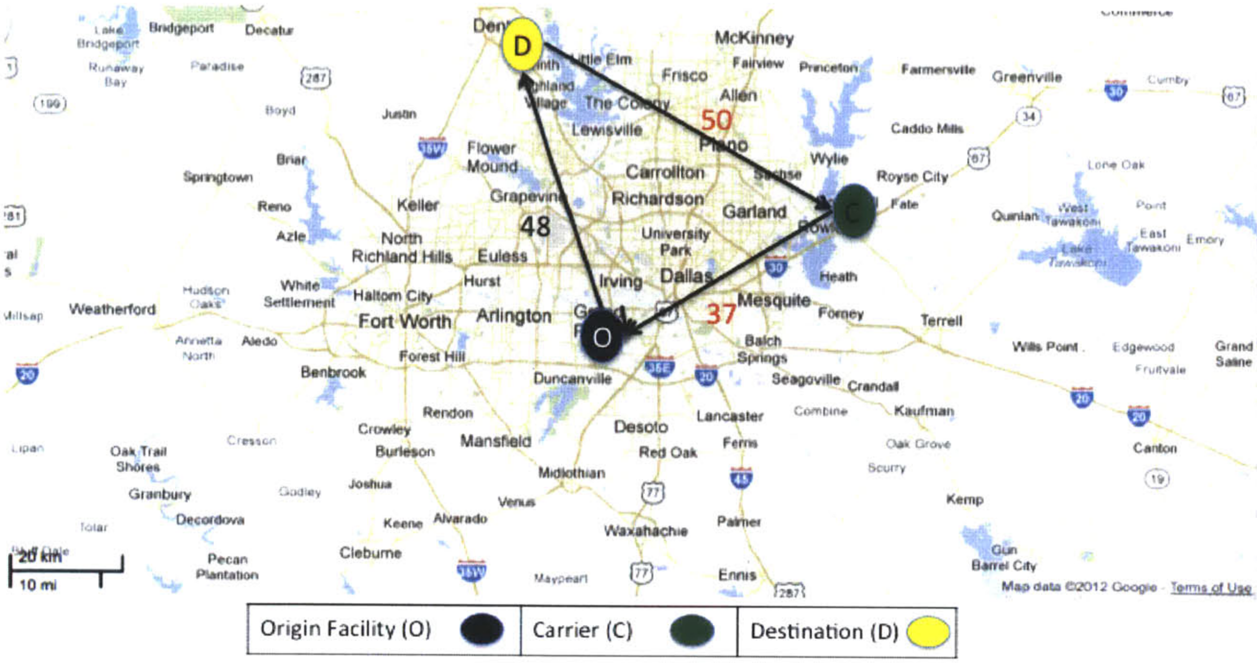


Figure 4-20 Carrier Location - Scenario 1A

Scenario 1B (Figure 4-21) shows what the network would look like to serve Sanger if FT moved its operations near Large Co.'s facility. Empty miles would decrease to 48 miles, which is only 50% of the total distance traveled. Since FT is co-located, they do not incur the initial empty miles to travel to Large Co. and only incur the empty miles on the trip back. With co-location, empty miles will always be decreased to the absolute minimum of 50% - anything above 50% shows some inefficiency within the network and room for improvement. Total cost from empty miles decreased to $78.88 resulting in 20.67% in savings per shipment compared to Scenario 1A. In this particular dataset, this lane was serviced 2,120 times meaning Large Co. could potentially save about 12% on this lane alone. For FT this situation means decreased empty miles, increased asset utilization, and the potential for more business from Large Co. due to its proximity and linehaul rates.

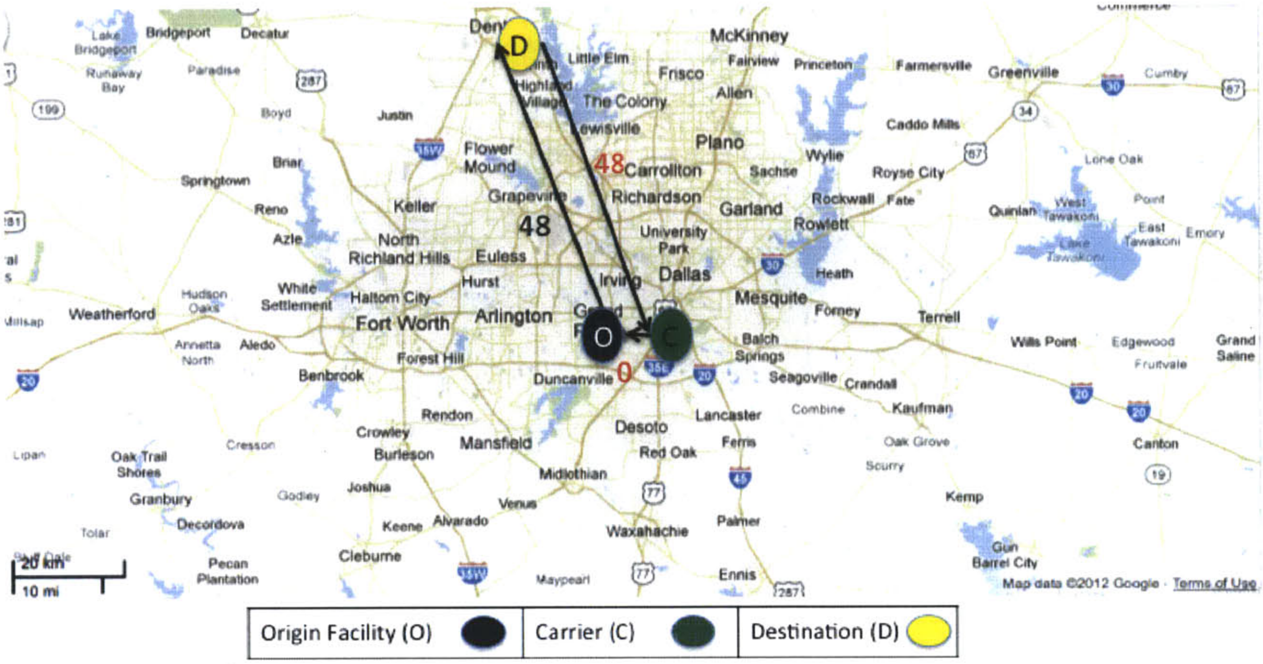


Figure 4-21 Carrier Location - Scenario 1B

Scenario 2A (Figure 4-22) shows a customer being serviced in Millsap, Texas. This destination is located almost 100 miles from Rockwall (58 miles from Large Co.). With 128 empty miles, they account for about 63% of the linehaul spend, so the optimization potential is 13%. Out of these 128 miles we can see that 70 miles or about 55% of the total empty miles can be avoided with carrier co-location.

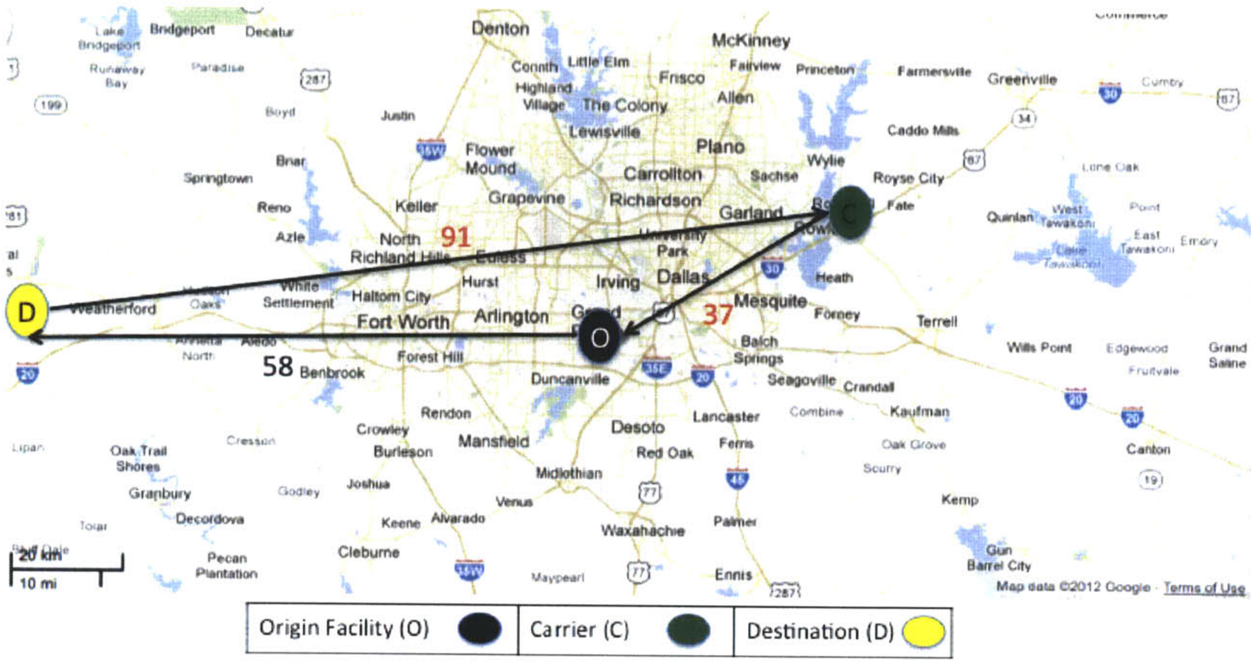


Figure 4-22 Carrier Location - Scenario 2A

In Scenario 2B (Figure 4-23), again we see co-location where empty miles have decreased to 50% of the total distance traveled compared to the 69% in Scenario 2A. Co-location saves Large Co. about 50% on empty mile cost per shipment for this lane. Not only does Scenario 2A cost Large Co. extra, but it also takes up more of the day for the FT driver, limiting their hours of service. In the time it would take FT to service one shipment in Scenario 2A, it could service almost two shipments in Scenario 2B.

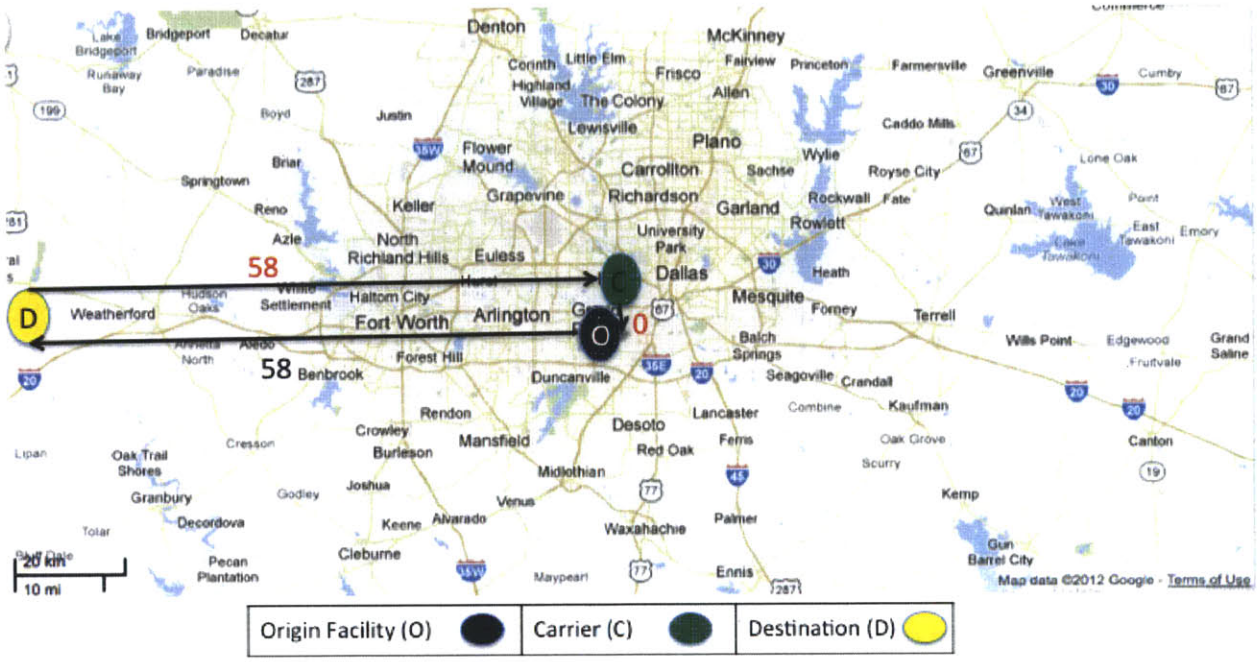


Figure 4-23 Carrier Co-Location - Scenario 2B

Table 4-14 shows what the impact of co-location would be if FT were to co-locate with Large Co. at its production facility in Dallas, TX.

Table 4-14 % Savings with Carrier Co-Location

Range	% Savings
40-60	20.84%
60-80	18.32%
80-100	10.67%
100-120	17.16%
120-140	8.32%
140-160	3.07%
160-180	16.08%
180-200	2.35%

Carriers can potentially run their equipment more efficiently and shippers in turn receive better rates, but there can be some constraints. For FT, it can be expensive to co-locate, not all lanes will have significant changes, and there is not always property available. For a shipper like Large Co., they can choose to select carriers for the bidding process based on knowing the location of the carrier and freight itself. Figure 4-24 shows three separate destinations and three possible carrier options. By drawing a straight-line between Large Co.'s facility and the carrier, and a perpendicular line traveling through Large Co., we are able to see the region best serviced by a specific carrier when attempting to limit empty miles (Figure 4-25 through Figure 4-27).

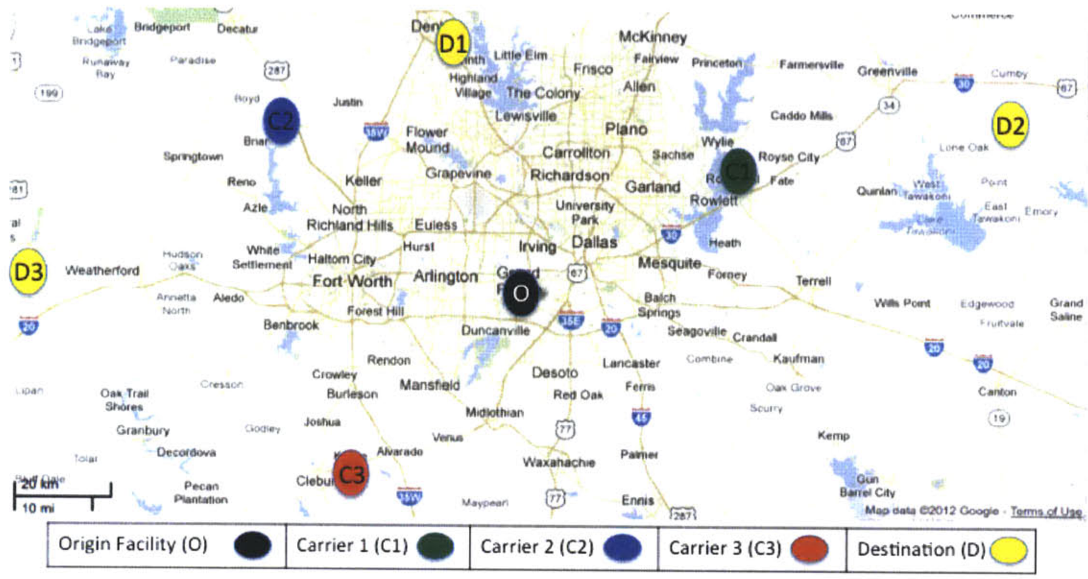


Figure 4-24 Potential Network Layout around Dallas

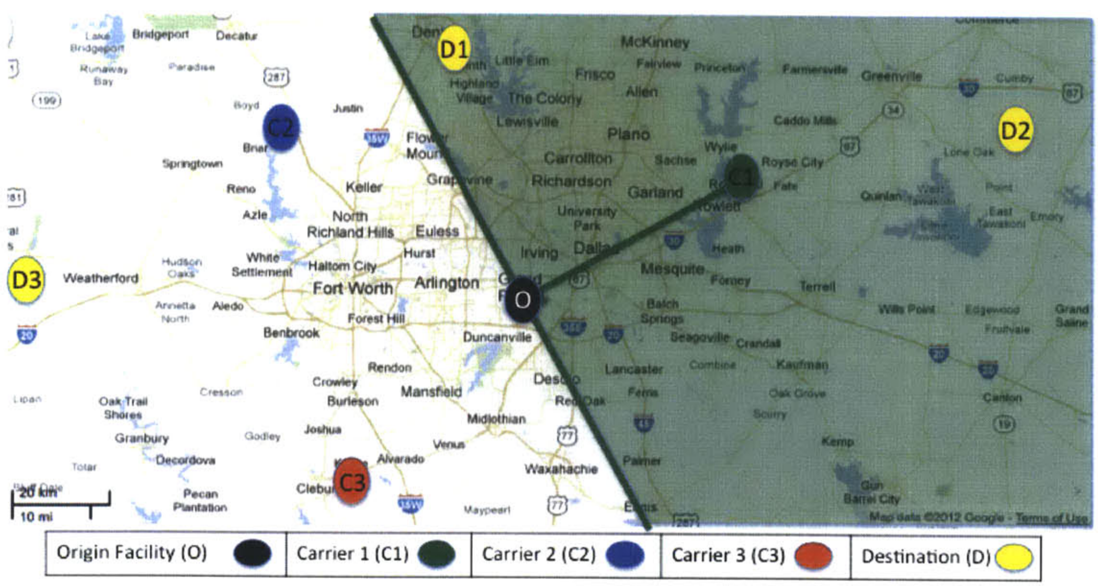


Figure 4-25 Best Serviceable Region for Carrier 1 (C1)

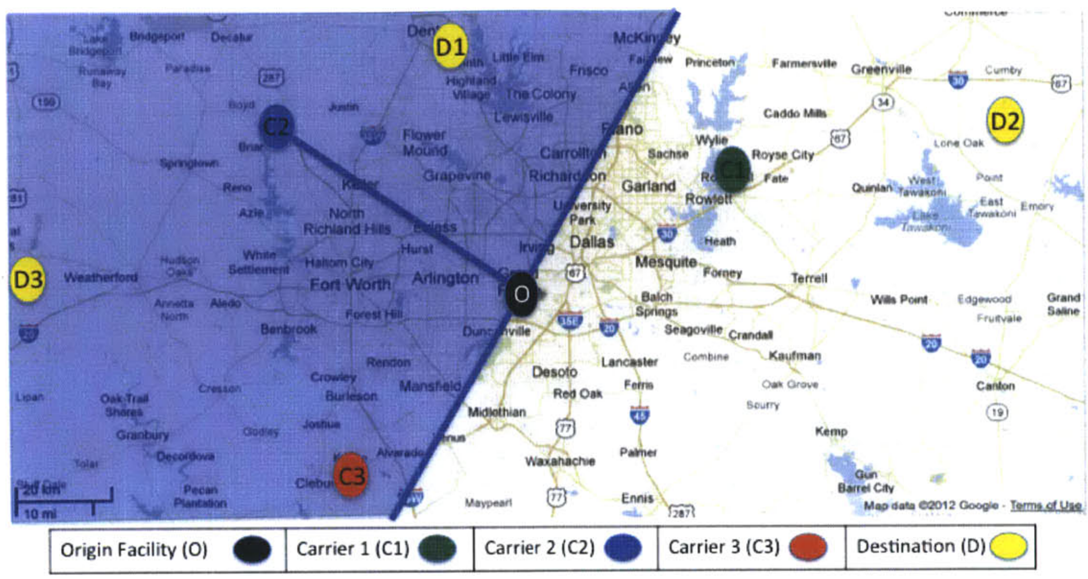


Figure 4-26 Best Serviceable Region for Carrier 2 (C2)

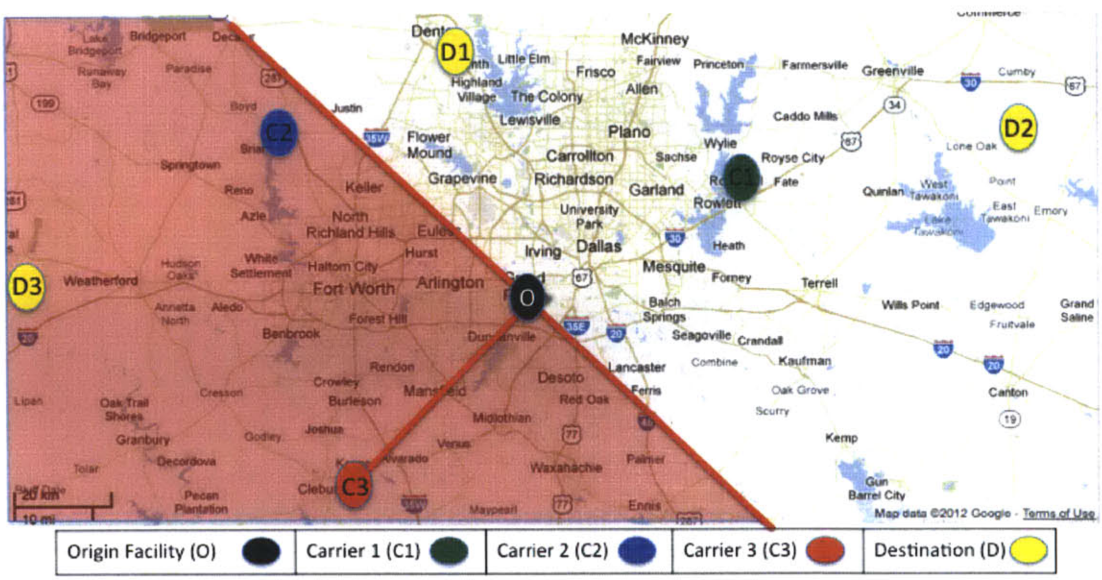


Figure 4-27 Best Serviceable Region for Carrier 3 (C3)

5. Discussion and Recommendations

In this section we are going to turn the knowledge we gathered through the data analysis and research process into actionable recommendations. The proposed solutions will serve as a framework that our sponsor company can use to improve operations. Since transportation management is a continuous process it needs to be maintained and monitored on an ongoing basis. We will provide relevant metrics and performance indicators for each recommendation, which will help to make the process sustainable.

5.1 Freight Procurement

First, we will focus on elements related to freight procurement. Even though Large Co. has a well-developed and organized procurement process, we will discuss additional strategic and operational improvements that can increase available capacity and reduce the amount of money spent on transportation.

5.1.1 Bid and Carrier Allocation Review

Currently, Large Co. conducts one major bid event a year and negotiates new lanes on an ad hoc basis as the demand emerges during the year. However, not only the shipper's network evolves; the network operated by each individual carrier does too. The changes can be both a threat and an opportunity for the shipper. While certain carriers shift their capacity, reject loads, and cannot service previously contracted lanes, others may have additional resources and be willing to fill the gaps of underperformance.

As Table 4-5 showed, the deterioration of service in the form of carriers not accepting tenders was a gradual process. Similar scenarios apply to price escalation as volumes go up on specific lanes. Being able to identify changes in demand and price early can help the company switch carriers or contract additional capacity.

Conducting a major bid once a year sets a solid framework for operations for the entire 12 months. However, periodic performance review is required to maintain the structure and have it work as expected. The metrics should be reviewed in a form that illustrates variability over and time allows Large Co. to spot trends. The most important indicators considered in the review should be:

- Rejection percent and depth per three digit zip lane, aggregation zone, and distance bracket
- Rejection percent by carrier
- Price escalation by shipment sequence and rank number on key heavy volume lanes
- Percent of contracted lanes going to the spot market

One thing to point out is that rejection by carrier will not equal rejection on specific lanes. Since we implement the notion of rejection depth, a shipment is only counted once, regardless of how many times it gets rejected. Depth provides an additional dimension of severity to rejection and its potential implications. As an example, shipment rejected once is covered at an average of 6% premium by a backup carrier. Shipments rejected at a depth of 10 carry an average premium of 26% and are covered either by a carrier with rates on file or in the spot market. The numbers can fluctuate by lane and time of the year, so monitoring lanes with the highest price escalation allows for identifying regions with the utmost impact on the shipper. A high number of rejections as well as high rejection depth signal trouble on specific lanes.

Focus on specific lanes will allow Large Co. to address potential problems early in the process. Controlling price escalation will ensure capacity robustness.

As we confirmed in our analysis, depth of rejections and lack of lane robustness have a direct impact on cost of transportation. When daily volumes fluctuate on specific lanes or are above originally expected numbers, the incremental shipments will be covered at a much higher cost than initially anticipated. To remedy these two factors, shippers can reassign carriers, redistribute volumes, or redirect more capacity to the spot market (local exchange in the case of Large Co.).

5.2 Building Robustness into Lanes and the Entire Network

As we discussed in section 4.4, lane robustness is a critical factor in maintaining stable prices and keeping rejection rates low on high volume lanes. This section will discuss multiple techniques that can enhance network resilience and help to improve carrier performance.

5.2.1. Broker Utilization

Higher broker utilization can be a tool to increase available capacity. Brokers, knowing they can expect a steady flow of business rather than being called during peak times, can grow their carrier base in the specific area and develop relationships with companies that have destinations where Large Co. has production facilities. One of the brokers (2012) we interviewed talked about their arrangement with a beer producer that is in close proximity to Large Co. Knowing that they can always get freight from Large Co., they can offer better rates and steady service to both companies.

Table 4-3 showed that broker use goes up with the number of shipments on a specific lane per day. That pattern confirms that brokers are an important source of additional capacity and that they provide it when asset based carriers do not have enough resources in a specific area.

Currently, Large Co. gives preference to asset based carriers for their consistency of service and familiarity with Large Co.'s freight. However, as Table 4-1 pointed out, broker use can go from 16% to as high as 42%, which shows there is a wide range of broker utilization that provides optimal performance.

Currently, brokers are most often selected as backup carriers with rates on file. As a result, they get engaged when capacity is getting tight. However, based on our previous industry experience, if brokers were given more steady business, they would be able to ensure that there is an available capacity in the vicinity of the shipping location and it could be utilized for shipments going in any direction. Just as carriers would do, brokers can find other customers that ship to where Large Co.'s shipments originate. Asset based carriers, as confirmed in our interviews, have a preference for destinations they normally go to, since they need to bring their equipment back to the domicile. In contrast, brokers can use carriers on a one-way basis only or find them loads going to other locations. A steady flow of business, as a percentage allocation on specific lanes, would allow brokers to develop repetitive business compared to filling a lot of ad hoc requests as occurs now. Over time, the steady flow of business would turn into a relationship between companies and serve as a base for future business.

Because of carrier/broker economics described in section 4.2.2 and price differences shown in Figure 4-4, developing capacity with asset based carriers on lanes shorter than 100 miles will result in a high service level and will contribute to creating a local pool of capacity. Since capacity provided by brokers is temporary, having a local carrier base could also be beneficial for longer haul lanes. Any lanes above the 100 mile mark present a great opportunity to be awarded to brokers. Increased broker utilization on lanes in the range of 100-200 miles could help to lower rejection rates. In this distance range, carriers make a decision about taking a load or not depending on the available backhaul. The one-way nature of brokered shipments could help balance the flows with capacity that does not have to return to base. Also, past the 100 miles mark, broker prices become comparable with what carriers have to offer.

As Figure 4-4 pointed out, there is a difference between average price for brokers and carriers for various distance ranges. The goal of broker utilization should be to continuously keep closing the gap. The less the difference in prices between brokers and carriers, the less the variability in price on individual lanes.

Additionally, creating broker capacity in the area could serve as a buffer to better serve low volume lanes and being able to respond to spikes in demand on high volume lanes (Table 4-2).

To measure the success of this recommendation, many metrics would need to be deployed. They would include rejection rates on specific lanes, regions, and distance brackets. Also, the impact could be visible in the average rate ratio between asset and broker based shipments. Price escalation for rejected shipments and rejection depth per lane would be used to measure the impact on available capacity.

5.2.2. Private Exchange as a Capacity Distribution Mechanism

Large Co. should increase utilization of private exchange to increase the amount of available capacity. By "private exchange," we mean allowing carriers that already have a relationship with Large Co. to bid on a certain portion of loads on a daily basis, rather than using allocation and backup mechanisms. Currently, the spot market for Large Co. represents only 5.8% of the total shipments. Moreover, the company only uses the ad hoc method as a last resort, in situations when contracted capacity is not enough to cover fluctuating demand or when lanes have no contracts in place.

During the normal tendering process, primary carriers are allocated a certain amount of volume on specific lanes. However, the volumes fluctuate, and whenever the primary carrier capacity is exhausted, shipments are tendered to backup carriers. Depending on the volumes on a specific lane, the routing guide can have a depth of up to 7-10 carriers. Every level deeper in the routing guide involves a price increase compared to what would have originally been paid.

On the other hand, sometimes the demand on a lane is less than what was originally projected to the carrier. In such situations, the primary carrier has some slack capacity, but at the same time is excluded from shifting that capacity to other lanes. Even though the primary carrier can potentially offer lower prices than what the backup carrier has already contracted.

Designating a specific amount of demand to a private exchange would allow the slack capacity to be reallocated to different lanes (Figure 5-1). For the spot market to work, though, that capacity needs to be large enough so that carriers can have enough volume to actively participate and diversify with lanes that fit within the carriers' existing flows. Limiting the capacity covered using routing guide or allocating a percentage to the spot market would give enough business to the backup carriers. At the same time though, it would leave some demand available to primary providers that have not filled their quota for the day on other lanes.

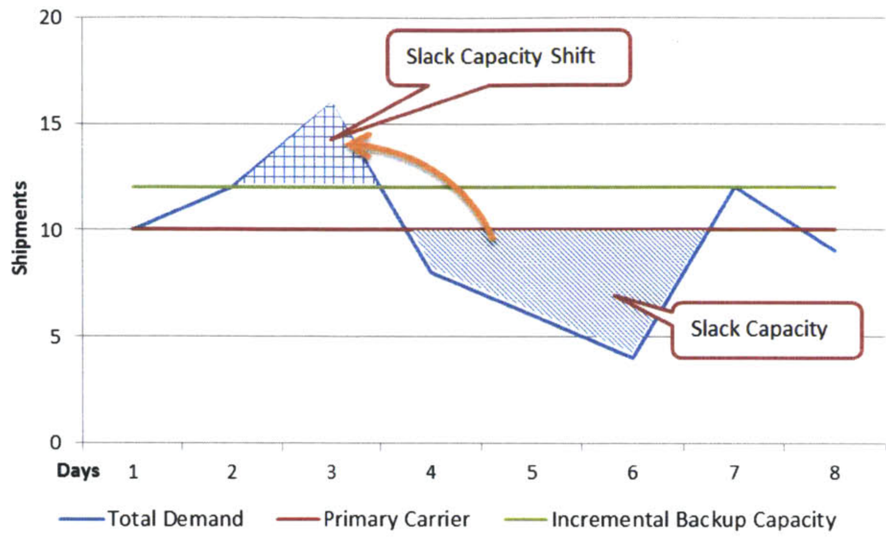


Figure 5-1 Slack Capacity Reallocation Schematic

From our conversations with Large Co., reallocation of capacity in real time is a significant problem. Often carriers with slack capacity can cover other lanes at lower cost, but because of the way the process is designed, they are not able to reallocate the additional demand between carriers. Providing the ability to carriers to reallocate their capacity on a daily basis would help them with equipment utilization and benefit Large Co. with better pricing.

A similar scenario could be applied to rejections. Instead of going 5-10 levels deep, shipments could be automatically sent to the spot market after 2-3 rejections. It would save time in the tendering process and potentially reduce costs.

The effectiveness of the process could be measured by price escalation on specific lanes as well as potential cost savings compared to the next available rate in the routing guide. Additional benefits for the carrier community could be measured through a carrier feedback mechanism and participation in the spot market process.

This recommendation would require further research and analysis of cost impact. Currently we were not able to use the spot market data to draw meaningful conclusions, since the data sample was small and the spot market was used only under special circumstances.

5.2.3. Rate Counteroffers

One of the subjects that came up during our interviews with carriers was the ability to give a rate counteroffer. Currently, Large Co. does not have a process in place to collect those. However, using the spot market could solve the problem. In situations where a backup carrier cannot cover a shipment at the contracted price but could to do so at a slightly higher rate, the carrier could submit a counteroffer, along with other carriers, in the spot process. This mechanism would allow Large Co. to pick the lowest cost alternative, and it would help the carriers optimize their equipment.

Using counteroffers would be a supplement to existing contracts and higher use of private exchange would only help to facilitate it. At this point, when shipments are not covered in the normal tendering process, every time they go to the spot market, as defined by Large Co., they are essentially sent to carriers for a counteroffer. The goal of the counteroffer would be to allow carriers that already have expertise on the specific lane to submit their best offer given current situation and prevent the price from escalation with carriers that would serve the lane on one-off basis. It is important to emphasize, though, that such a mechanism would only be used in times of limited capacity when shipments are already rejected, carry heavy price premium, or are sent to the spot market for bids.

However, as in the case of capacity reallocation, the spot market size would have to be much larger to provide enough opportunities for carriers to compete and develop habits of participation.

The metric to see if the process works and is helping Large Co. would be the number of times a backup carrier was selected in the spot market as the lowest bidder. Material savings could be calculated based on the price difference between the selected carrier and the next consecutive bidder from the routing guide.

Primary carriers would need to be excluded from the process as the opportunity can create a moral hazard: carriers could try to reject loads so that they can bid a higher rate, hoping to get more money.

5.2.4. Change Allocation Method from an Absolute Number to a Percent

Currently, Large Co. allocates volumes to primary carriers based on an absolute number of capacity provided by a specific carrier (Figure 5-2). This means that if there are two primary carriers on a specific lane and average demand on it is 50 shipments, then the first carrier, with allocation of 40 loads, keeps taking shipments until its capacity is depleted. On the other hand, the second carrier, with an allocated capacity of 10, only gets what is above 40. As a result, the first carrier always gets the freight, while the second carrier only gets involved when the demand exceeds a certain threshold. If the volumes do not go over a specific number of shipments, the second primary carrier does not get any freight.

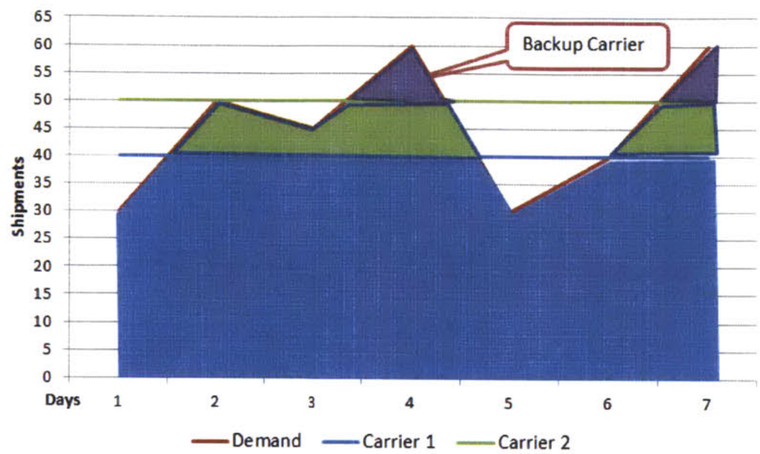


Figure 5-2 Allocation of Freight to Carriers Based on Absolute Numbers (Current State)

However, the very term "primary carrier" means that the carrier will always get freight on a specific lane. Using the absolute number of allocation puts the second primary carrier in a role of a backup provider with 100% service commitment, whereas it should be treated in the same way as any other primary carrier.

Additionally, as we could see in the data, even primary carriers reject loads. So, making sure the second primary carrier is always actively involved with ready capacity available could lower the number of rejected loads and improve carrier relationships over time.

To change the situation, we are proposing an allocation method based on percentages with capacity limits. Figure 5-3 illustrates how the mechanism would work. In the case described in Figure 5-2, Carrier 2 does not get loads on some days or only gets a small portion of what was allocated, while Carrier 1 is running at full capacity almost all the time. Even though a lane has a significant flow of volume, from the perspective of Carrier 2, it looks like a lane with spotty demand.

In the newly proposed scenario, each carrier gets a proportional amount of volume on a specific lane and both of them keep capacity available to Large Co. What is more, the shipments are now tendered to both carriers throughout the process, without waiting for anyone's capacity to be exhausted. So, even though Carrier 2 may only have 10 trucks committed, it would be tendered loads in the early stages of the process. That way Carrier 2 would have a full understanding of the volumes and would be less affected by the variations in demand. If the volume stays steady, specific lanes can actually become a part of carrier's regular network, rather than just a contractual obligation that has to be met on an ad hoc basis.

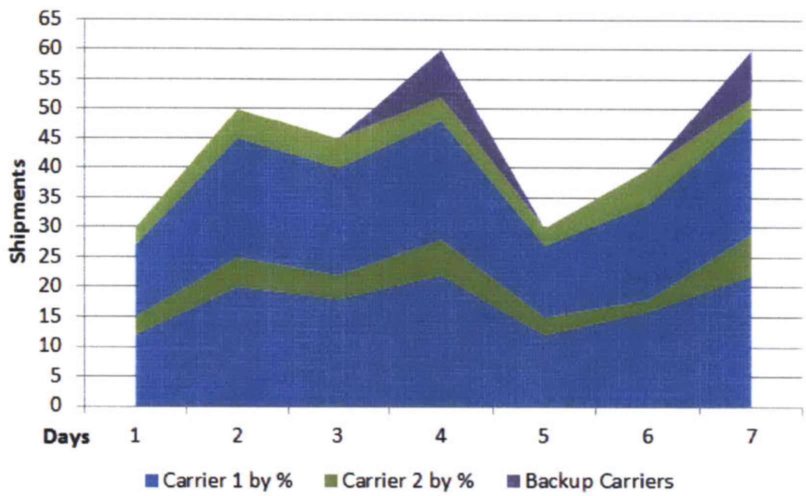


Figure 5-3 Allocation of Freight to Carriers Based on Percentages with Capacity Limits

With capacity limits in addition to percentage allocation on lane basis, the process would make sure carriers are not tendered too many loads when the demand spikes up.

The carrier rejection rate and number of times shipments are covered by a backup carrier would be indicators of the process's success. Also, a carrier satisfaction survey would be able to provide insights on how carriers could receive an increased variety of business.

5.2.5. Focus on the Low Performance Range between 100 to 300 Miles

Large Co. needs to focus on developing additional capacity on lanes in the range of 100 to 300 miles. As our research suggested, lanes in this range reach the highest number of shipments per day on specific lanes, experience the largest price escalation, and are the most prone to rejections. Also, as we confirmed in our interviews with Large Co., the company is trying to get away from long haul shipments and target shorter distances. Building strategy around this specific bracket of 100 to 300 miles would have the biggest impact on transportation performance in the close future.

No single recommendation can provide a solution to all the issues in this distance bracket. However, numerous tools and mechanisms discussed in this section offer guidance on what can be done for the specific distance range.

5.3. Lane Aggregation

As we discussed in section 4.6, lane aggregation can help to reduce variability of demand by grouping multiple lanes. Also, a smaller number of lanes to manage lowers the amount of operational work needed to maintain the complexity of the system.

However, in spite of the benefits, there is no single best way of aggregating lanes. In our study we looked at multiple options and built an aggregation model that reflects the methodology we think would help to organize Large Co.

5.3.1. Circle-Satellite Lane Aggregation Model

Figure 5-4 presents the model we designed based on Large Co.'s network structure. All lanes up to 50 miles are aggregated in 10 mile increment categories. So, when carriers bid on a lane, they do not bid on a specific destination, but on a distance range they are going to service. Any time a shipment is in a specific circle, the carrier charges the same rate.

The other portion of the model addresses remote zones, in this case called satellites. A satellite can be defined as a three digit zip region, city area, or a custom zone built around a place with concentrated demand.

Usually, the demand between 50 and 100 miles is not concentrated enough to use the 10 mile circles and on some lanes carrier economics often drive the price. Therefore for the green regions either the satellites or the circles methodology can be used to procure freight.

For every specific location, point-to-point lanes can be established. However, as the demand spreads geographically in close proximity, the point-to-point destinations would evolve into the satellites.

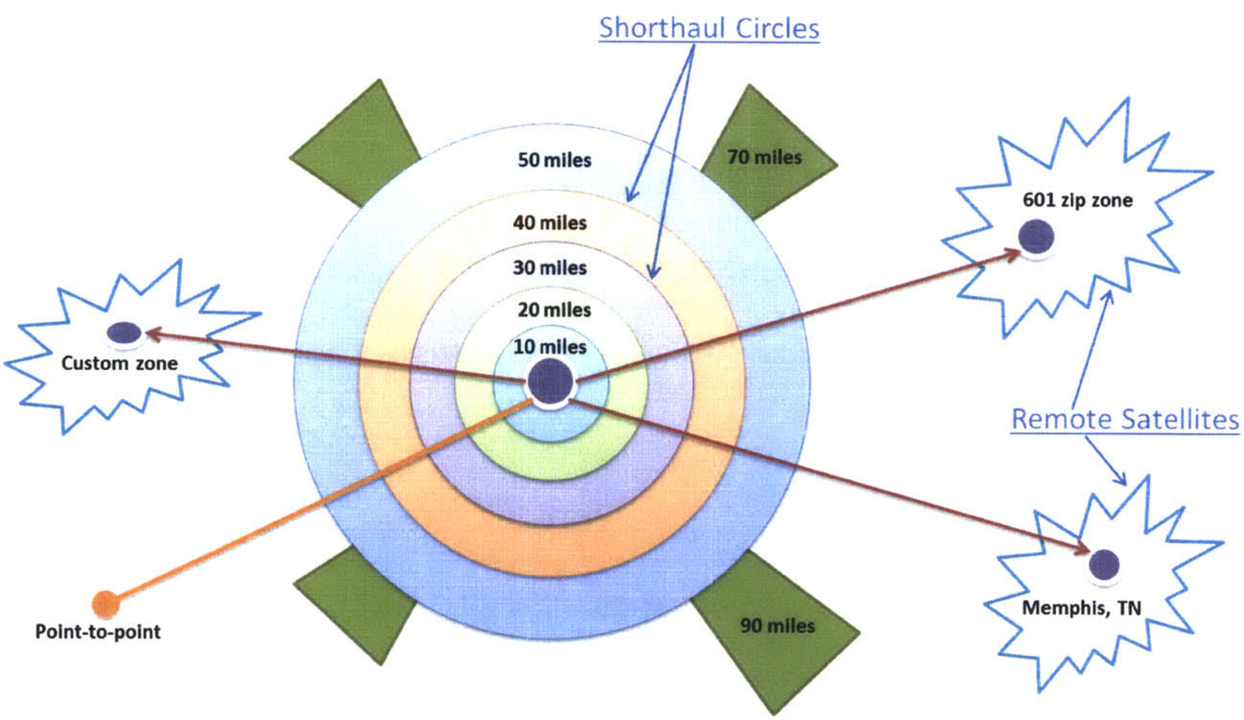


Figure 5-4 Circle-Satellite Aggregation Model

During our discussions with short haul carriers, they expressed interest in doing the circle zone based pricing. For the satellites, city or three digit zip based regions are already used in the industry, yet designing custom zones would need to be tested with specific carriers. Presenting a region that incorporates multiple three digit zip zones could be confusing to a carrier. However, as our attempts in the data analysis proved, aggregation in areas of highly concentrated demand would bring benefits of reducing variability and operational complexity.

5.3.2. Aggregating Around Busy Clusters

Currently, Large Co. aggregates lanes under three digit zip zones when the demand is less than 60 shipments per year. This approach provides a level of operational simplification, but the full array of benefits from aggregation are accomplished through combining low volume lanes with those that carry a lot of traffic, not just putting together low activity lanes. As we can see in section 4.6.2 on the remote cluster analysis, the slow volume lanes benefitted the most in terms of reduced variability when aggregated with high volume lanes.

In order to combine around busy lanes, just doing a three digit zip aggregation is not always enough. As Table 4-8 and Table 4-10 showed, the aggregation regions span 3-8 zones with three zip codes.

Furthermore, pooling high volume lanes together can also provide benefits. In the Columbus, Ohio, study, two main lanes drove the entire demand. When they were combined, the variability of total demand came down and the total required capacity to provide a specific service level was reduced by 11%.

5.3.3. Summary

Lane aggregation presents a great opportunity for Large Co. to reduce variability and provide a more stable view of demand across multiple lanes. Our study only focused on the aspect of managing capacity and operational efficiency. Further studies would need to be done to reflect the financial impact aggregation would have on the cost of transportation. Currently, we did not have sufficient data to make reliable conclusions about that. However, the initial results are very promising and were well received by the carriers we interviewed.

5.4. Carrier Location

As discussed in section 4.7, carrier location in relation to shipping destination and shipper can have a significant impact on the linehaul rate. The decreased efficiency of driving empty and the lost hours of service by the driver result in $1.64 per empty mile being incorporated into the linehaul rate. Because every network will always have some amount of empty miles, it is important for a carrier and shipper to distinguish which empty miles can be limited. Limiting the amount of empty miles within a network can make the network more efficient by increasing a carrier's asset utilization -- that is, it allows the shipper to move more freight on the same number of trucks while paying less.

5.4.1. Co-Location

After looking at the different scenarios, we recognized that carrier co-location is by far the best option when attempting to limit empty miles. Carrier co-location will always result in decreasing empty miles to 50% of the total distance traveled, generating the highest savings for the shipper, and increasing the utilization of the carrier's truck and drivers. Since 61% of total distance traveled by FT in the current network is empty miles, co-location can potentially offer over $200,000 in savings or about 18% of the current Large Co. transportation spend for these 3,270 shipments.

5.4.2. Serviceable Region Map

Combining the regions created in section 4.7.4 shows us the area best serviced by each carrier and provides us with a rubric to select carriers based on their locations and shipping destination. For example, in Figure 5-5 we can see that shipping destination 1 (D1) is best serviced by carrier 1 (C1) and carrier 2 (C2) because it falls within each of their serviceable regions. During the carrier procurement process, C1 and C2 would be invited to the auction, assuming they would offer the best rates due to their close proximity to the shipping destination. In this specific example, C1 would best service D2 and almost all shipments west of Large Co.'s facility.

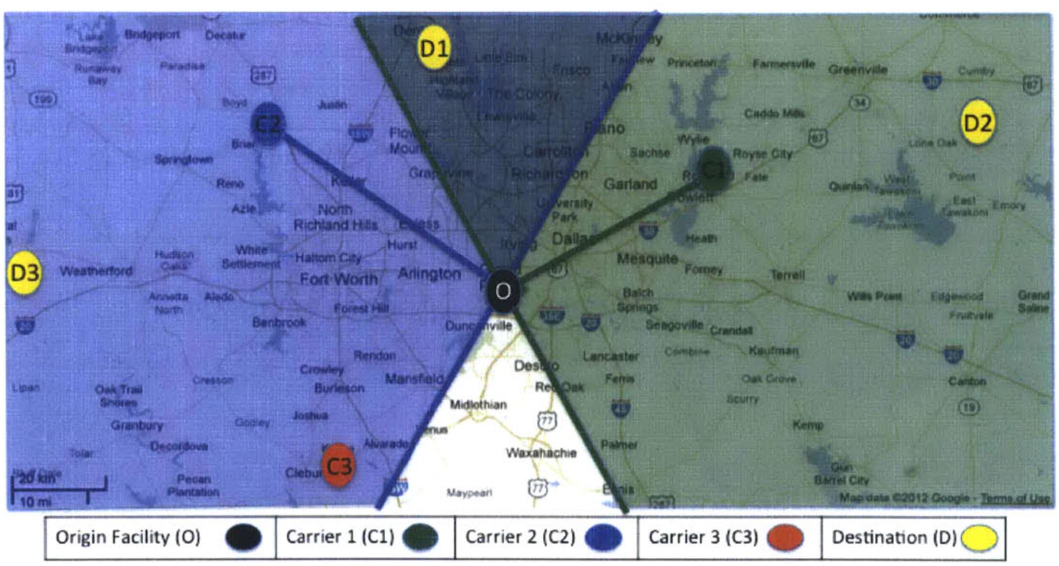


Figure 5-5 Serviceable Regions for Carriers 1 (C1) and Carrier 2 (C2)

5.4.3. Summary

Although carrier co-location is the best option when attempting to eliminate empty miles, it can be expensive and difficult to coordinate. Our recommendation is that FT moves a portion of their operations for co-location, singling out specific shipments where co-location offers the most to gain. By keeping most of its operations in Rockwall and positioning a small portion of its equipment near Large Co., FT would be able to service the shipments it is close to while reaping the benefits of co-location on lanes it is nowhere near.

If co-location is not feasible, then some of the same benefits can be found in our serviceable region analysis (section 5.4.2). As new lanes are added to Large Co.'s network, the shipper can single out the carriers that would offer the most competitive rates. Planning strategically during the carrier procurement process makes it much easier to execute during operations.

6. Future Research

Our analysis covered a wide range of aspects of TL transportation that affect pricing and capacity. However, in our research we identified important topics that may need to be explored, but were either beyond the scope of the project or appropriate data was not available at the time. The additional subjects include:

- Drop-n-Hook In-Depth Analysis – Investigate the material and operational benefits of dropping off equipment at a loading facility in a short haul network. The study would account for the total time it takes a carrier to load a shipment when yard space and loading capacity are limited. It would also examine the financial benefits of setting up a separate yard or optimizing an existing facility.

- Factors Affecting Lane Robustness – Analyze external factors that affect lane robustness and design policies that could help shippers secure capacity without price escalation.

- Identify Potential for Creating Custom Aggregation Zones – Develop additional areas for creating cross zip or city surrounding zones. Investigate effects of aggregation on demand variability, price sensitivity, and carrier willingness to bid on non-standard regions.

- Lead Time Impact on Rejections and Price Escalation – Analyze how the amount of lead time given to the carriers affects shipment pricing and rejection rates. Investigate the issue from the perspective of various distance brackets and sources of capacity.

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