Accounting for Uncertainty:

An Empirical Analysis of Truckload Budgeting

by

Seyed Mostafa Taheri
MSc, Information Technology, University of North Carolina

and

Shayna Moliver
BA in History, University of Connecticut

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Signature of Author: _____
Department of Supply Chain Management
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Signature of Author: _____
Department of Supply Chain Management
May 10, 2024

Certified by: _____
Dr. Chris Caplice
Executive Director, MIT Center for Transportation and Logistics
Capstone Advisor

Accepted by: _____
Prof. Yossi Sheffi
Director, Center for Transportation and Logistics
Elisha Gray II Professor of Engineering Systems
Professor, Civil and Environmental Engineering

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ABSTRACT

This study investigates the United States full truckload procurement process and persistent issue of budget overruns faced by shippers during their budgeting. Despite planning through Requests for Proposals (RFPs) that forecast shipping volumes and secure contractual rates with carriers, shippers regularly confront unplanned expenses surpassing their budgets. The key problems addressed are the discrepancy between planned budgets and actual expenditures, accentuated by the dynamics of the spot market and the unpredictability of freight volumes. Utilizing data from 13 shippers' Transportation Management Systems (TMS), provided by C.H. Robinson's TMC division, this research delves into the factors contributing to budget overruns. The analysis covers 196 transportation procurement events across 13 shipper companies over six years, highlighting a consistent trend of budget overruns, with some instances reaching up to 180%. The methodology employed includes a quantitative model that helps shippers plan their budgets. The findings underscore the necessity for a more sophisticated budgetary framework that integrates spot market factors, enabling shippers to anticipate and manage transportation costs more accurately. This study not only sheds light on the complexities of freight budgeting but also suggests a shift towards incorporating data analytics to enhance forecasting accuracy and budget reliability.

Capstone Advisor: Dr. Chris Caplice
Title: Executive Director, MIT Center for Transportation and Logistics

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- From both of us

The unconditional love, support, and friendship from my mother and father throughout my entire life have always been the source of my strength and motivation. I am deeply grateful for everything they have done for me.

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- Mostafa

None of this would have been possible without the unfaltering support of my wife and partner, Noam Mantel. You believed in me when I did not believe in myself, when I found a path, you encouraged me to take it, and while on that path you shouldered the responsibilities of our life to allow me to achieve what I have. Thank you for all your love and support.

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- Shayna

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1 INTRODUCTION

The full truckload (TL) sector, a cornerstone of the United States transportation market, accounts for a substantial portion of all domestic freight activities. In 2022 alone, TL services represented nearly $404 billion of the domestic transportation market, underscoring its dominance and the dependency of numerous industries on this shipping mode (Zimmerman et al., 2023). Despite detailed planning through Requests for Proposals (RFPs), shippers regularly face budget overruns. An evaluation of 13 shippers across 196 transportation procurement events over six years reveals consistent overruns, varying from 6% to as much as 180% (280% of their budget), highlighting the complexity of budgeting in this sector. Our findings underscore the need for clear budgeting guidance and a strategic budgeting tool to offer resilience against unplanned expenses.

The capstone is structured as follows: Chapter 1 introduces the motivation, the problem statement, and the research questions, leading into our project goals and expected outcomes. Chapter 2 evaluates the current state of practice, detailing routing guides, spot market dependencies, and the overarching freight budgeting landscape. In Chapter 3, we outline our data and methodology, clarifying the data summary and terminology while examining procurement big-bids and mini-bids along with lane categorization. Chapter 4 presents our results and analysis, analyzing procurement events, shipper classification, budget overruns, and volume variability. Finally, Chapter 5 culminates in our conclusions and recommendations, where we summarize our findings into actionable insights.

1.1 Motivation

The annual truckload freight procurement process involves shippers, carriers, and brokers beginning with an annual Request for Proposal (RFP). In this annual event, shippers forecast volume for planned (contractual) freight and secure contractual rates through RFPs — a reverse auction, where

transportation service providers (carriers) are awarded the right to transport freight on specific lanes for a contracted price and duration. These contracts are binding in price but not in volume requested by the shippers, nor in capacity supplied by the service providers (Caplice, 2021).

Routing guides operationalize RFP-derived contracts within Transportation Management Systems (TMS) by assigning lanes to carriers. Although they help in tendering shipments to the primary carrier, routing guides are not reliable for budgeting, failing to account for unplanned freight, changes in shipping patterns, and carrier failures. For the remainder of this capstone, we consider the output of the RFP as the defacto budget.

The truckload market cycles between tight (when demand exceeds supply) and soft (when supply exceeds demand). During a tight market, spot market rates exceed contract rates, carriers often break contracts to opt for the higher rates, leading to what is known as routing guide failures. When the routing guides fail to tender a load to the primary carrier, shippers typically turn to higher-cost backup carriers or the spot market following what is called a waterfall. Shippers also resort to the spot market in order to ensure tender acceptance on less desirable lanes. Spot market transactions occur at current market rates, offering immediate load (shipment) acceptance. The spot market is useful for unbalanced, inconsistent, and low volume lanes, where they put a portion of their planned freight directly into the spot market (direct to spot) as a strategy to improve performance (Oliver & Zheng, 2023). Since these direct to spot loads are not typically included in the routing guide, they are not necessarily included in the shipper's budget.

In addition to the strategic use of the spot market unplanned freight (transactional) is often tendered through the spot market. Spot rates fluctuate above and below contracted rates, depending on market conditions, and can be as much as 20% to 30% higher (Caplice, 2021). Off-cycle bids (detailed in Table 2), represent additional forms of unplanned spend. These lanes are not included in the annual

RFP and materialize within the year they are bid, further complicating the budgeting process. The unplanned shipments may stem from factors like acquiring new customers, altering product distribution, opening new facilities, or encountering issues with planning (Caplice, 2021). These unplanned shipments are frequently defined by their low volume, irregular patterns, and unpredictability, which result in uncertainties and significant fluctuations in unplanned freight volumes (Caplice, 2021). With the spot market accounting for 11% to 25% (Caplice, 2023) of the overall $400 billion total freight market (*Economics and Industry Data*, n.d.), even marginal forecast improvements would reduce shippers' reliance on more expensive backup and spot services, which could have profound financial implications.

1.2 Problem Statement and Research Questions

C.H. Robinson, handling $30 billion in freight and 20 million shipments annually, notes that its customers frequently face budget overruns, often failing to account for costs from routing guide failures (C.H. Robinson, 2023). As Jordan Kass, President of TMC, a division of C.H. Robinson, explains:

> "In a freight marketplace where rates can change rapidly and are constantly being influenced by a variety of factors, pinning down an accurate transportation budget is a challenge. Many shippers we work with use historical cost data and rates from their RFPs as the primary inputs to their budget process. They're in need of a more accurate and data-driven forecasting model." (J. Kass, personal communication, April 30, 2024)

Our analysis reveals budget overruns of up to 180%, which pose a substantial challenge for planning and operational strategies for these companies.

Our capstone addresses the fundamental question of how shippers can create better transportation budgets. Our research examines how a shipper should estimate their TL transportation budget for the following year to account for unplanned spend. We hypothesize that the best way to

achieve the project's goal will be to use data analytics methods to characterize and quantify the sources of rate and volume variability. We utilized datasets from C.H. Robinson's TMC division. These datasets encompassed route-guide visibility, pricing information, lane characteristics, awarded shipments, and non-awarded shipments.

Table 1 shows how we categorized different shippers. Analysis of data from 13 shippers, as shown in Figure 1, reveals that shippers consistently experience budget overruns. Annually quantified budget overruns across three shipper categories from 2016 to 2023 demonstrate the variability in budgeting challenges faced by different sizes of shippers.

Figure 1: Transportation Budget Overrun per Shipper Based on Their Category of Average Actual Spend

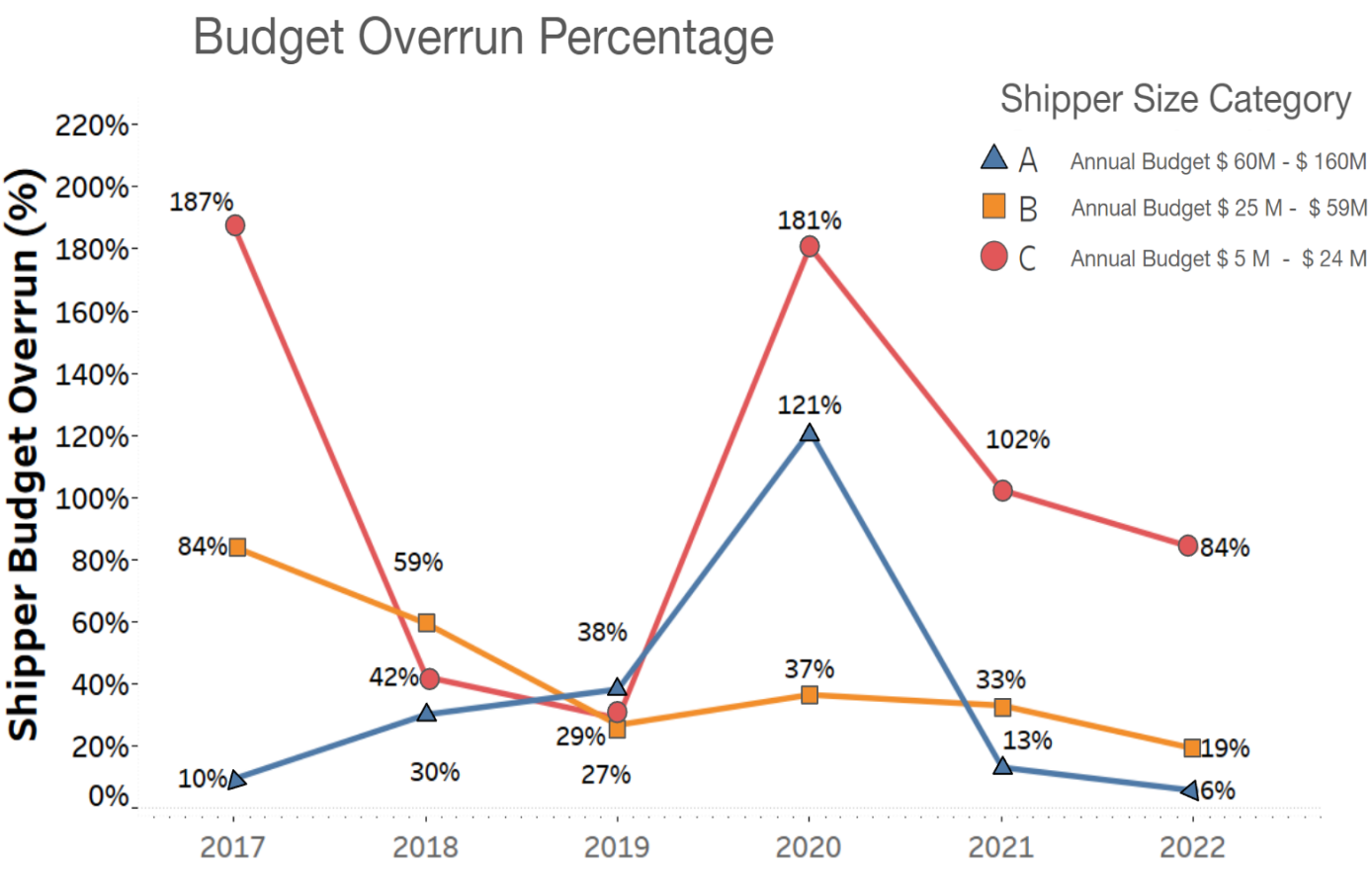


Table 1: Shipper ABC Categorization Based on Annual Materialized Spend

Shipper Category	Category Percentage of Aggregate Expenditure	Number of Shippers	Minimum Annual Spend	Maximum Annual Spend
A	75%	4	$60 M	$160 M
B	15%	4	$25 M	$59 M
C	10%	5	$5 M	$24 M

The budget overrun for each category is computed by determining the difference between the actual annual spend, which includes spending in the spot market and off-cycle bids, and the planned annual budget of lanes contracted during that specific RFP, then expressing this difference as a percentage of the planned budget.

The planned budget for each year is calculated based on the expected volume (from the RFP) and the cost per load (CPL). Due to the unavailability of actual budget data from the historical records of each shipper, the expected annual spend from the RFPs are utilized as proxies for the actual budget. This approach assumes that the RFP outputs closely reflect what shippers would have budgeted for their transportation costs.

The accompanying Figure 1 depicts the percentage of budget overrun across the three shipper categories from 2017 to 2022. Excluding the sharp fluctuations observed in year 2020 due to the Covid19 pandemic, we observe a decreasing trend in the percentage of budget overruns for Category A shippers, without a clear trend for Category B and C shippers. Since 2020, shippers across all categories have had a decreasing trend of budget overrun. This may suggest that larger shippers are better able to predict their overall spend compared to smaller shippers. We discuss the budget overrun in more detail in Section 2.3.2 and Section 4.2.1.

1.3 Project Goals and Expected Outcome

Our research establishes a recommended budgetary framework for TL transportation that incorporates specific freight profiles of shippers. The project includes a quantitative model to forecast a budget range given specific shipper profiles. Our research focuses on the limitations of traditional budgeting methods, which depend heavily on annual Requests for Proposals (RFPs) and routing guides but fail to accommodate unplanned freight and ghost lanes—lanes designated in RFPs that see no actual shipment. Our findings advocate for a shift towards more precise budgeting practices that incorporate past year's lane level data and use the spot market as a strategy. We developed a strategic budgeting tool aimed at enhancing consistency and efficiency in budgeting. This tool will help shippers more accurately forecast spot market expenses and adds lane consistency insights to refine budget projections.

The capstone is organized to walk the reader through our comprehensive analysis—from reviewing current budgeting practices to delving into the data and methodologies that support our conclusions. Our research concludes with actionable insights and recommendations, setting the stage for future research and implementation in the industry.

2 State of the Practice

This chapter discusses relevant background topics and includes routing guide, the spot market, and freight budgeting, ghosting, routing guide failure, and unplanned spend.

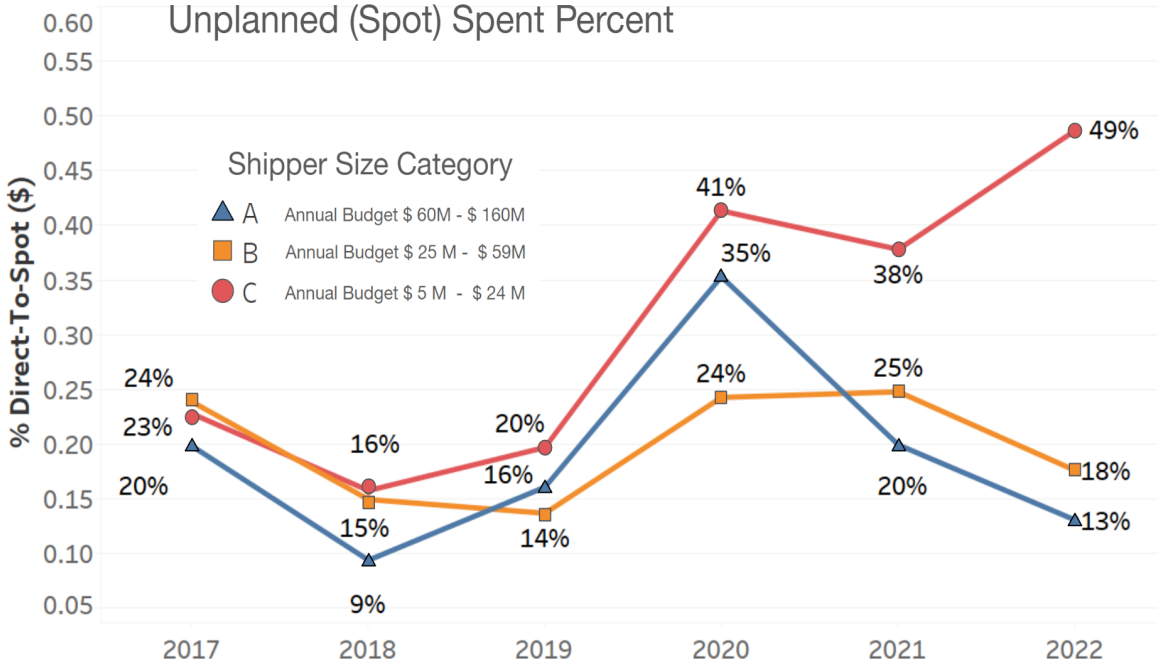
2.1 Routing Guides

Routing guides are the center of the complex interplay between shippers, carriers, and brokers (Zimmerman et al., 2023). While the RFP process creates the contractual relationship between shippers and carriers, it is the routing guide that operationalizes contracts in the transportation management system (TMS) allocating lanes to carriers. Essentially, routing guides reflect a shipper's forecasted volume by listing all the lanes (from the RFP) where a tender might occur, thus forming the basis of a shipper's annual budget.

2.1.1 Budgeting Challenges

We investigated the limitations of routing guides in budgeting, noting their inability to incorporate significant freight volumes which leads to recurrent budget discrepancies. Figure 2 illustrates that in 2022, shippers with an annual spend below $25M experienced an average of 49% of their shipping spend as unplanned, directly resorting to the spot market.

Figure 2: Percent of Transportation Spend in the Spot Market Per Shipper Based on Their Category of Average Actual Spend



The spot market is defined here as unplanned spend not included in the RFP and not part of an off-cycle bid. Approximately 16-49% of Category C shippers' spending and 9-35% of Category A shippers' spending were in the spot market and therefore excluded from the RFP budget. This lapse in the budgeting process highlights the necessity for a more sophisticated framework. Such a framework should seamlessly incorporate the spot market into a shipper's financial planning strategies.

Alnajdawi and Jimenez (2020) provide further insight into this issue by examining routing guide performance and characterizing factors that lead to budget overruns. Their study found that for three shippers in 2019 "...the percentage of loads that were planned and on budget is 80% on average during the year" (Alnajdawi & Jimenez, 2020). They also noted that "volume deviations contribute to budget overruns more than price deviations," suggesting that high-volume lanes tend to be more predictable in terms of budgeting (Alnajdawi & Jimenez, 2020).

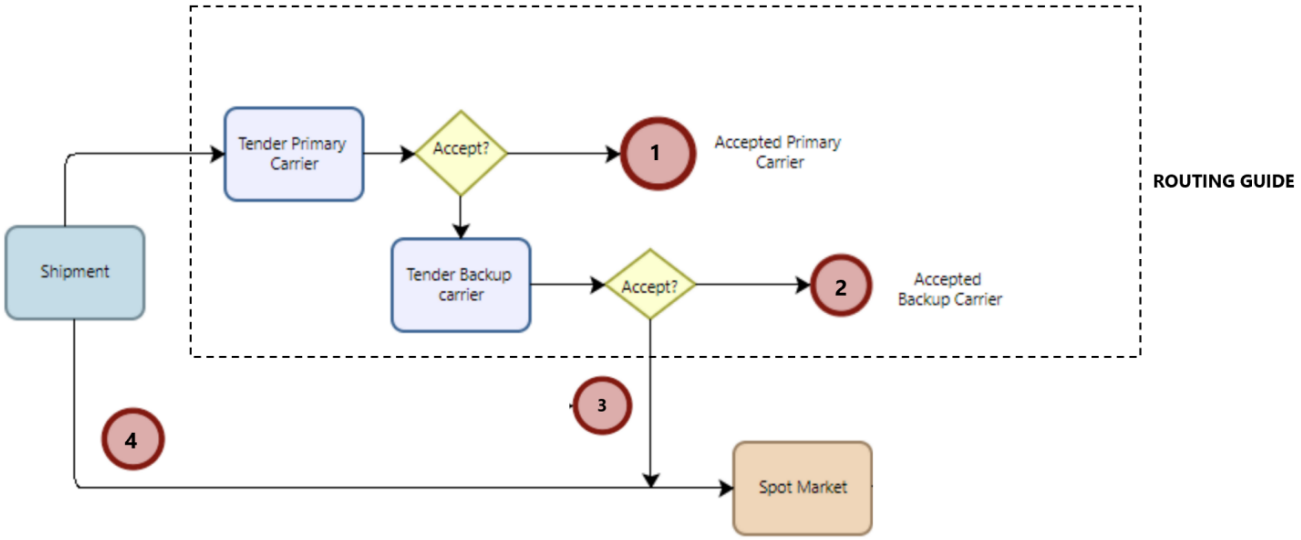
Our research corroborates these findings as we observed that shippers averaged budget overruns every year. Our data indicate the probability that a lane would repeat, based on prior year volume, is more than 70% if the lane had more than 12 loads, as can be seen in Section 4.3. We also see that average CPL variation remained generally unchanged as the number of active weeks increased. Interestingly, Alnajdawi and Jimenez (2020) noted that the length of haul of a lane was not a significant factor in causing budget deviations. Rather, lanes within a single state were more susceptible to variations, regardless of their length. While our study does not focus on length of haul, we did determine that lanes with higher volume and consistency are more likely to repeat the following year. Alnajdawi and Jimenez (2020) provide valuable insights into how lane characteristics impact shippers' budgets.

2.2 Spot Market

Effective spot market budgeting requires understanding the tender process, including scenarios where shipments bypass routing guides and go directly to the spot market, as shown in Oliver and Zheng's (2023) Figure 3. Here are the key paths shown in Figure 3's waterfall chart:

1. **Acceptance by the Primary Carrier:** When a shipment materializes, the shipper (directly or through a broker) tenders the shipment to a primary carrier. This primary carrier then has the option to either accept the load or reject it.
2. **Accepted by the Backup Carrier:** If the primary carrier rejects the load, it is offered to a backup carrier. While varying widely by shipper, the load may cycle through up to five backup carriers, though potentially more, before it is accepted or fails the routing guide (Aemireddy & Yuan, 2019).
3. **Unplanned Spot Market:** In cases where the routing guide fails, the shipper resorts to the spot market as the last option.
4. **Direct to Spot Market:** Unlike tendering to a contracted carrier within the routing guide, a spot market tender is subject to the current market price conditions and has no service-level constraints.

Figure 3: An overview of the tender process from initial load tendering to carrier acceptance



(Oliver & Zheng, 2023)

Understanding these paths is crucial in developing effective strategies for budgeting in the context of the spot market's price volatility and unpredictability. We are not suggesting that the routing guide be abandoned altogether. Aemireddy and Yuan's (2019) research shows that "...staying in routing guide will result in lower transportation cost than going to spot market regardless of the market dynamics" (p.21). Our research did not directly investigate the correlation between spot market use and budget overruns; however, we did find that larger shippers had lower overall percentages of budget overruns and percentage of spot market use compared with smaller shippers.

2.3 Freight Budgeting

Budgeting in the truckload freight industry requires a strategic allocation of resources that extends beyond forecasting demand volume and lane pairings. Effective budgeting requires a comprehensive financial strategy to ensure cost-efficiency and effectiveness in freight transportation. Complicating more straightforward freight budgeting is the irregularity of the RFP bidding process, ghosted lanes (lanes awarded in the RFP that never have shipments tendered, thereby impacting budget

accuracy) routing guide failure, unplanned “off-cycle bids” (contracts established outside the main annual RFP cycle), and unplanned spot market spend.

While routing guides are crucial for operationalizing contracts within TMS, assigning specific lanes to carriers, they are not designed to handle the financial intricacies of freight budgeting. They are fundamentally operational tools, meant to facilitate the tendering process based on contracted rates and lane assignments.

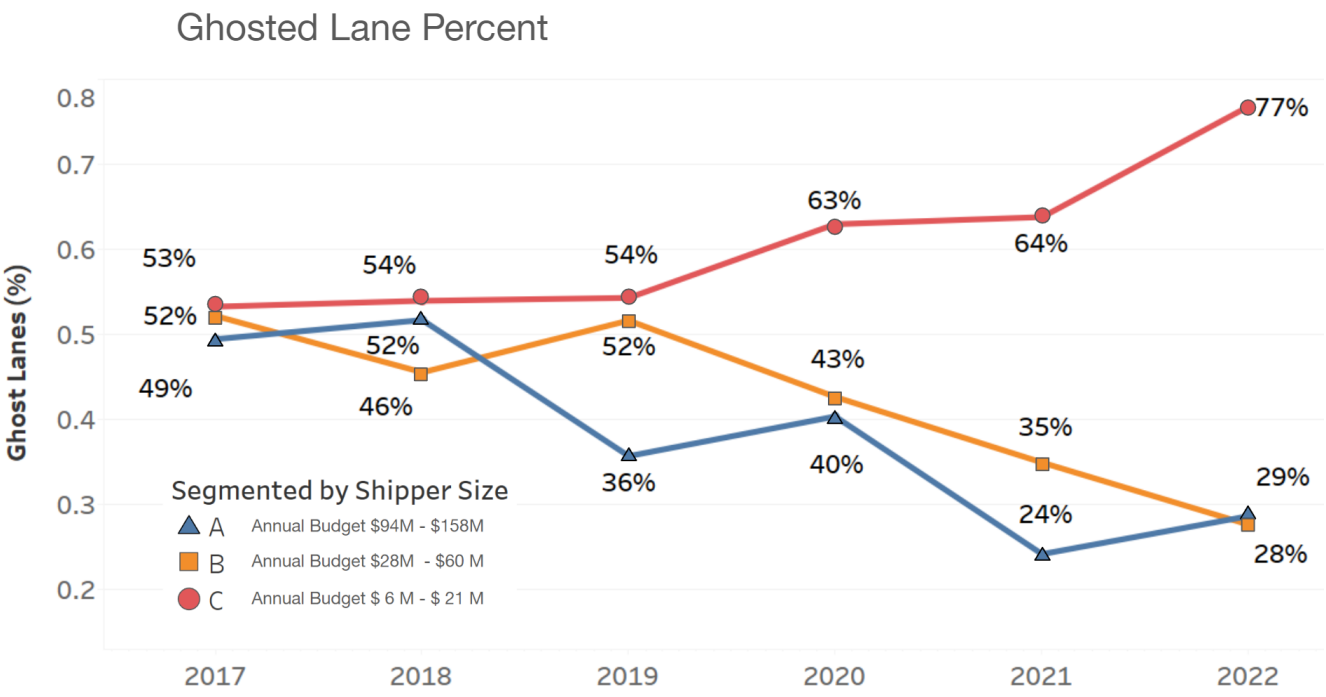
2.3.1 Irregularity of the Request for Proposal (RFP)

Common knowledge in the shipping industry is that budgets are traditionally derived from the previous year's transportation expenses, drawing extensively from each shipper's annual RFP. Contrary to the assumption of a single annual RFP, we found that shippers conduct as many as 20 RFPs throughout the year. We have classified these RFP’s into “big-bids” defined as covering more than ⅓ of total forecasted number of lanes, and separately as smaller "mini-bids" where less than ⅓ of the total number of lanes were procured. In addition to these, “off-cycle” bids (outlined in Section 3.2.2 in Table 2) introduce further complexity. These bids involve tendering loads based on contracts obtained in big-bids or mini-bids outside the specific RFP cycle. The extensive time investment required for planning these RFPs — three to six months, and one to two weeks for a mini-bid — highlights the significant resources allocated to these procurement activities (Caplice, 2021). This aligns with the type of resource allocation O’Mahoney et al. (2013) observed and their advocacy for rolling forecasts. The variability in the size and frequency of these procurement bid events, with some accounting for more than half of a shipper’s lane procurements, and others for less than a third, adds complexity to budget planning.

2.3.2 Ghosted Lanes

A significant time investment in RFPs and routing guides is notable because up to 80% of contracted lanes never actually materialize (Acocella & Caplice, 2022). These "Ghosted Lanes" are detailed in both Acocella and Caplice (2022) and Liu and Miller (2021) as lanes awarded to carriers during an RFP but having no volume tendered during the contract duration. As we can see in Figure 4 our analysis shows the ghosting trend across different shipper categories.

Figure 4: Percent of Ghosted Lanes per Shipper Based on Their Category of Average Actual Spend



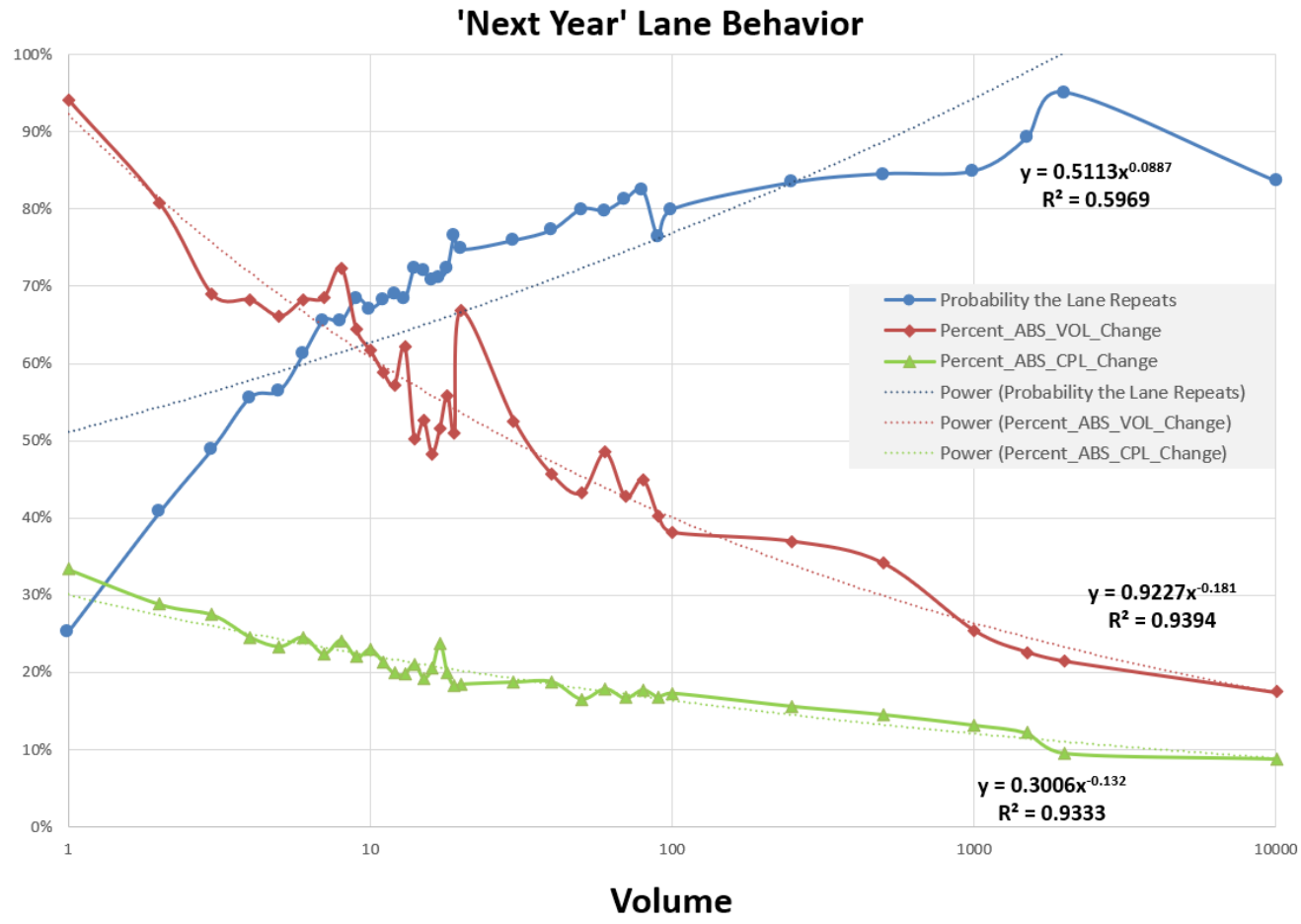
In 2022, we see that smaller Category C shippers, with an annual spend of $5M to $24M, have as many as 77% of their lanes ghosted. In stark contrast, the larger Category A shippers, with an average annual spend of $60M to $160M, show a lower incidence of ghosted lanes, with 29% ghosted lanes, suggesting that larger shippers may have more robust forecasting or utilize their contracted lanes more effectively. For Category C shippers, despite 53% to 77% of their planned lanes not materializing, they experienced budget overruns averaging between 29% and 187% over our six-year study, as shown in

Figure 1. We observe an increasing trend in the percentage of ghosted lanes for Category C shippers, alongside a declining trend for Category A and B shippers. The high rates of ghosted lanes suggest that the budget should be reduced and spend fall below their budget and yet it does not. Many shippers may be allocating financial resources based on inaccurate forecasts, contributing to budget overruns and wasted resources.

2.3.3 Routing Guide Failure

The unique contracting nature of the trucking industry, characterized by the enforcement of shipping rates without guarantees of capacity or volume, necessitates a budgeting approach that accommodates unplanned spend. Acocella and Caplice (2023) note that if the primary contracted carrier rejects a load, shippers using backup carriers may face costs that are 9%–35% higher than the original rate, highlighting the financial impact of routing guide failures. With frequent routing guide failures, shippers are reliant on the spot market for high variability, low-volume lanes as shown in Oliver and Zheng's (2023) work. This study corroborates these findings, revealing that lanes with fewer than 12 loads per year experience a CPL change exceeding 20%. Additionally, lanes tendering more than 14 loads annually demonstrate a likelihood of repetition exceeding 70%, as illustrated in Figure 5. By analyzing patterns in routing guide failures and their correlation with shipment frequency, we have developed a more predictive budgeting tool that can help reduce the incidence of budget failures and improve financial control.

Figure 5: Lane Consistency Behavior Based on Volume of Loads in Current Year



We considered unplanned spend both as spend that went directly to the spot market, and spend on "off-cycle bids," lanes that had been previously or subsequently contracted outside of the specific RFP event being evaluated. With these dual definitions we are better able to assess the full impact of unplanned spend as it relates to each RFP budgeting period. Our findings suggest strategies that shippers can employ to account for more unplanned freight to minimize budget overruns and adequately allocate resources for unforeseen expenditures.

3 Data and Methodology

This research utilized data from C.H. Robinson's TMC division, focusing on full truckload (TL) loads transported within the United States. We analyzed these data over a contract period we defined by the 12 months following the "Effective Date" listed in the CostQuotes file, which contains routing guide and contracting information. Since the actual volume awarded in the RFPs was not available, we used the lane volume and spend from the previous 12 months as a forecast for the subsequent year. This method enabled us to compare forecasted spend and volume against actual outcomes, although ideally, we would have used the actual volume awarded in the RFP, though it was not retained by the TMS.

3.1 Data Summary

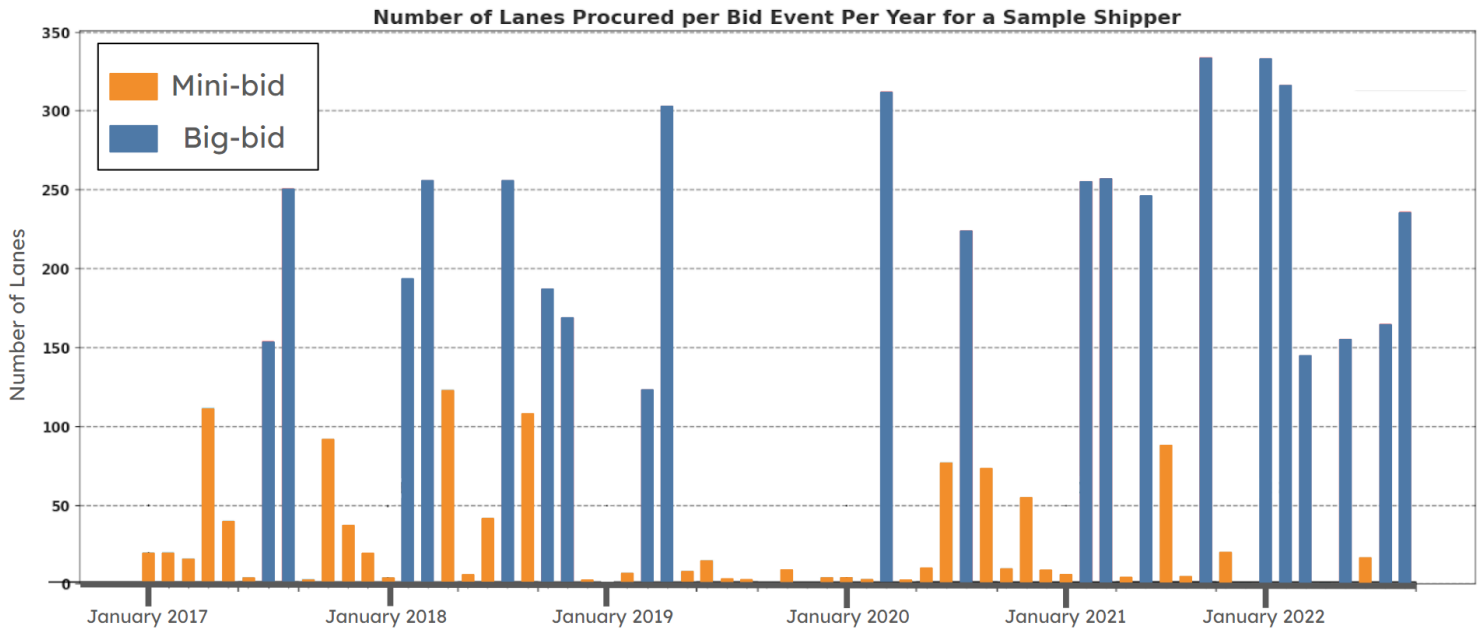
The data set compiled from two sources provided by our sponsor includes the CostQuotes and Loads files. The CostQuotes file details the lanes awarded to carriers, the contracted costs, and includes nearly 14 million unique contracts. The Loads file records the physical movement of shipments across almost 80,000 distinct city-state origin-destination pairs, showing whether shipments were managed by a primary carrier or routed through the spot market. Of the 79 shippers originally provided, 13 had data complete enough for us to perform our analysis. Together these files capture the actual execution and outcomes of truckload procurement and delivery for TMC's shipper customers.

We assessed the materialized lane volume for each shipper over 12 months, comparing it to the volume forecasted from the previous year. A budget was determined by analyzing the expected load volume and cost for the 12 months prior to each RFP's effective date. We employed the CalculatedTotalCost field to compute the total projected spend, thus facilitating an accurate budget projection for the forthcoming year.

3.1.1 Procurement Big-bids and Mini-bids

In Section 2.3.1 of the State of the Practice, we detail our criteria for classifying procurement events into "big-bids" and "mini-bids," based on the number of lanes involved. Big-bids encompass events where more than one-third of total lanes are procured, while mini-bids include smaller-scale events. The classification occurs based on the month of highest CostQuotes activity, which we use to pinpoint the annual RFP for each shipper. This pivotal month informs our broader analysis, recognizing that shippers' procurement may involve multiple events, not just a single main bidding event annually. Figure 6 visually represents these events with a sample shipper, highlighting big-bids in blue and mini-bids in orange, to demonstrate the diversity of procurement activities throughout the year for a typical shipper.

Figure 6: Example Shipper Showing Big-Bid and Mini-Bid Procurement Events Across Six Years



3.1.2 Lane Categorization

Lanes, defined as unique city-to-city pairs, are categorized in Table 2. Importantly, lanes that entered the spot market do not possess any QuoteID in the CostQuotes file and have never been part of any bid, whether planned, PreBid, PostBid, or MixedBid processes. This absence from the formal bidding process distinguishes them from planned procurement lanes, which are classified based on their anticipated operational usage as specified in the shipper's RFP.

Table 2: Shipper Lane Categorization

Lane Category	**Big-bid** Contracted	**Mini-bid** Contracted	Volume **Materialized**	Lane Categorization Logic
Planned Lanes	X	-	X	Lanes included in the annual RFP, where shipments occur at contracted rates (QuoteIDs) established during the RFP.
Ghost Lanes	X	-	-	Lanes procured during the RFP but have no materialized shipments on them.
Spot Market Lanes	-	-	X	Lanes not included in the RFP (new lanes), lacking contracted rates (QuoteID). Shipments on these lanes are procured in the spot market.
PreBid Lanes (Off-cycle)	-	X	X	New lanes procured through off-cycle bids (mini-bids) in the 12 months preceding the RFP. They materialize in the current year (12 months following the RFP which includes the month of RFP).
PostBid Lanes (Off-cycle)	-	X	X	New lanes procured during off-cycle bids mini-bids in the 11 months following the RFP. They materialize in the same year.
MixedBid Lanes (Off-cycle)	-	X	X	New lanes procured both during off-cycle bids mini-bids in the 12 months preceding the RFP (PreBids) **and procured again** in the 11 months following the RFP (PostBids). They materialize in the same year.

3.1.3 Lane Behavior Analysis

Before analyzing lane behavior, we first needed to refine these data. We filtered out entries with cost per load (CPL) values exceeding $10,000, which were considered extreme outliers, or falling below $100, as such low figures are typically not viable for carriers. We also removed any instances with missing data. Subsequently, we calculated the probability of lane volume recurrence in the following year, the percentage change in volume, and the change in CPL for the next year, based on the current volume.

For each unique Origin-Destination (O-D) pairing we sought to understand how lane consistency —specifically the number of active weeks—could inform future lane behavior and, by extension, budget forecasting. The 'Activity Date' for each load was used in deciding the week of activity. We then calculated the count of unique weeks per lane, using a combination of Branch Code and Activity Year, to analyze patterns of lane utilization over time. The week date system led to a count of 53 weeks for certain entries. To ensure consistency, especially in leap years, we standardized the week count to a 52-week year. For 2023, our dataset extends only through September, which could impact the predictive accuracy regarding the probability of lane repetition for any of the six (out of 196) procurement events that occurred post-September 2022. We will take this into account when analyzing the results for 2023.

4 Results and Analysis

In the Results and Analysis section, we present the outcomes of our data analysis, examining the procurement patterns and behaviors of shippers from 2016 to 2023. This section delves into budgeting patterns, identifying persistent overruns and contrasting strategic practices across different shipper categories. We explore how routing guides, often relied upon for budgeting, fail to accommodate fluctuations in freight volume and unplanned spending. Additionally, the analysis categorizes shippers by annual spending to illustrate how transportation budget size impacts different shippers in different ways. On the lane level, lanes operate the same way regardless of the category of shipper procuring them. The chapter further investigates how consistency in lane usage can lead to more reliable budget forecasts, offering a foundation for addressing the primary research question of improving budgeting accuracy amidst the inherent unpredictability of freight transport.

4.1 Procurement Events

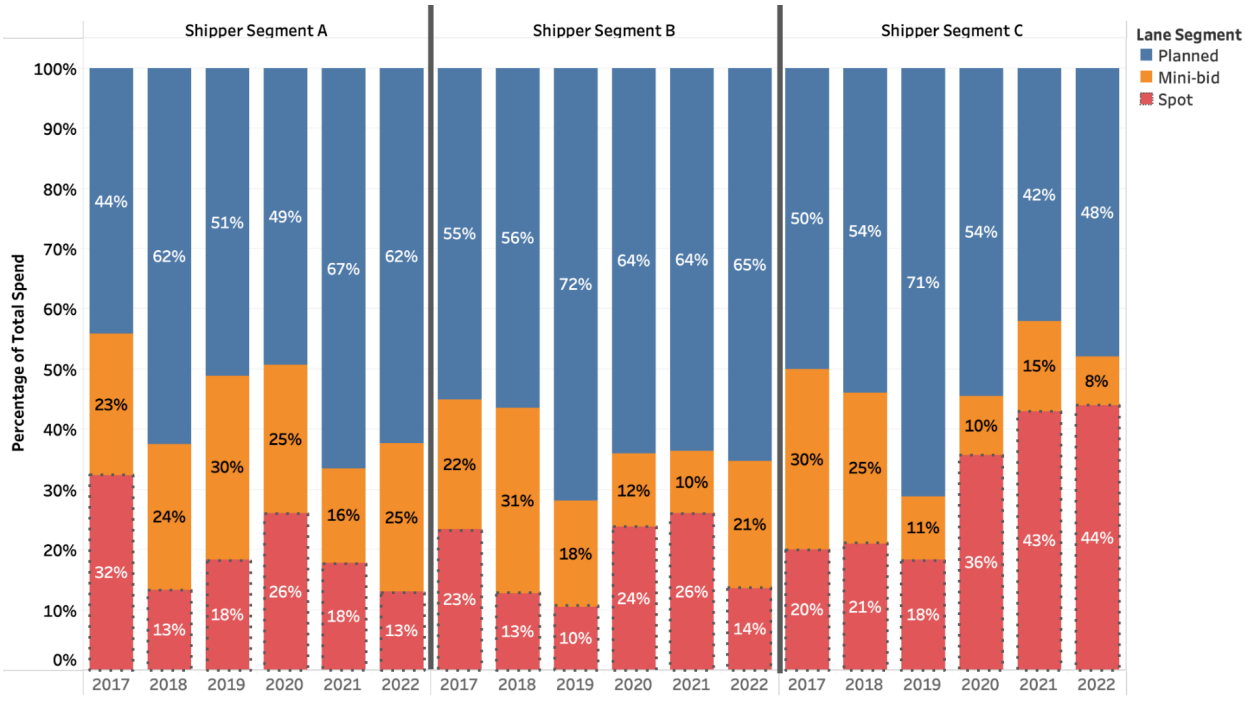
Here, we analyze the strategic implications of multiple procurement events and their impact on budgeting. For instance, in Figure 6, we see the complex reality of multiple procurement events, providing insight into their practical frequency and size, and their implications for annual budgeting processes.

In order to assess shippers' annual budgets, we sought to identify their annual procurement event during each fiscal year. Our analysis showed that shippers perform more continuous procurement through multiple RFPs throughout the year. As seen in Figure 6 this sample shipper had 10 procurement events in 2017 alone. The 2022 bidding data for this shipper illustrates the challenges of creating budgets based on a single annual procurement event. Notably, this shipper engaged in seven big-bid

events, with several involving more than 50% of their total unique lane count. These events represent only planned spend, whether or not it materialized.

However, in Figure 7 we see a trajectory of procurement patterns across various shipper categories, examining the proportions of spending on planned (big-bids), off-cycle (mini-bids), and the spot market. These data highlight the evolving landscape where shippers, particularly within Category C, are recalibrating their spend towards the spot market. A discernible shift is observed within shipper Category C, where post-COVID trends indicate an increase in reliance on the spot market, averaging around 40% of their total annual spend, compared to the less than 20% total annual spend pre-COVID. This change in procurement behavior suggests a potential departure from mini-bid investments towards the more flexible and immediate spot market solutions.

Figure 7: Percentage of Total Spend Across Shipper Categories by Big-Bids (Planned) Mini-Bids and Spot Market Spending



4.2 Shipper Classification

After establishing how we would evaluate a shipper's budget, we segmented shippers by their total annual spend. Initially, we tested shipper lane volume and bid size to categorize shippers. These did not generate clear trends. Categorizing based on total annual spend resulted in the most discernible patterns. We also explored categorizing shippers by industry verticals, such as Food and Beverage, Automotive, among others. However, it became evident that this would not yield robust insights as some verticals had only a single shipper represented. Table 1 shows how we categorized shippers by their share of the total annual spend, expressed as a percentage of the aggregate expenditure.

Our analysis reveals significant variances between forecasted and actual freight spend, with budget overruns showing a clear correlation with the shipper's annual budget size. In Section 1.2, we categorized shippers into three categories—seen in Table 1—based on their annual spend. Seen in Figure 1, Category C shippers, with annual budgets below $24M, consistently encountered the highest percentage of budget overruns, averaging 87% when excluding the anomalous year of 2020. This figure dramatically overshadows the overruns experienced by their larger counterparts in Category A, with annual budgets over $60M, where overruns fluctuated more modestly between 6%-38% (excluding the COVID year 2020).

While budget overruns varied across the years, there was a notable increase in overruns for Category C shippers as seen in Figure 1. In contrast, Categories A and B display a less pronounced volatility, suggesting more stable budgeting practices or possibly more effective utilization of their procurement strategies. We can see that Category B has an overall decreasing trend with an average of about 44% overrun while Category A has an approximately 19% budget overrun. These findings underscore a pressing need for smaller shippers, in particular to reassess their budgeting methodologies. The consistent underestimation of freight costs not only indicates a gap in their

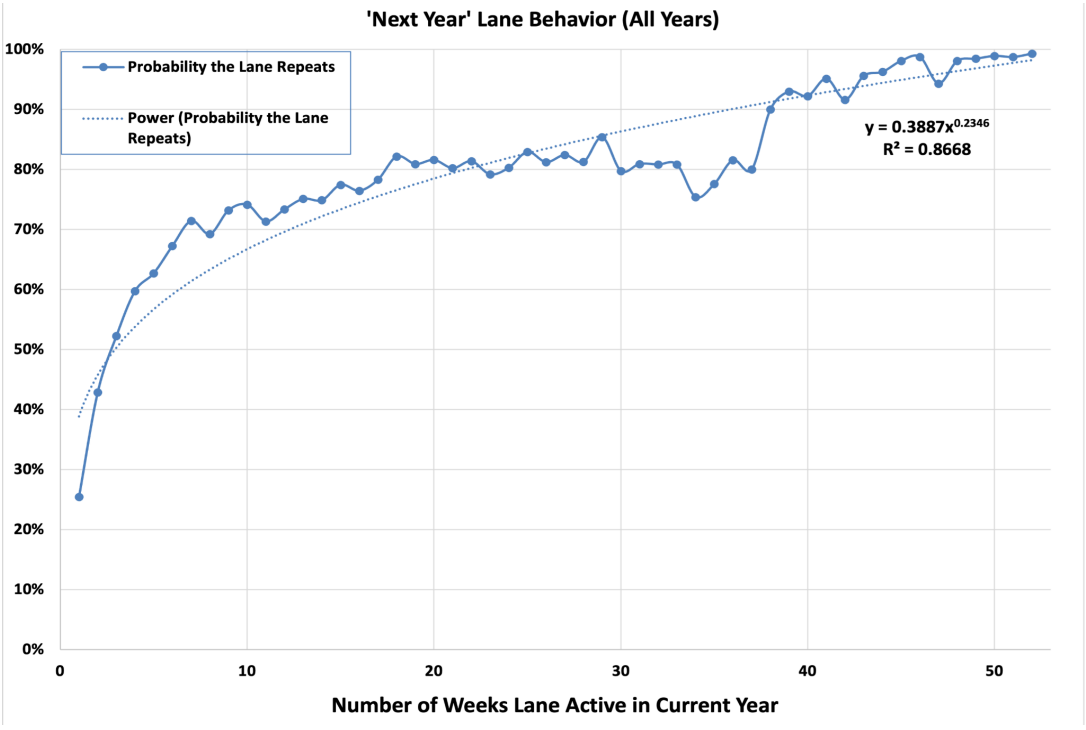
forecasting models but also an opportunity for significant improvement compared to their larger counterparts.

4.3 Lane Consistency

Our empirical analysis has uncovered distinct, repeatable patterns that have significant implications for budget predictability and planning. The study demonstrates that lane behaviors, including cost and volume fluctuations, are consistent across various scenarios and do not vary with a shipper's annual spending. These findings suggest broad applicability for our insights into freight budgeting practices.

As seen in Figure 8, these data indicate a strong likelihood of a lane repeating when it has activity for more than 12 weeks. Lanes with 13 to 52 weeks of activity have a 75% - 99% probability of repeating the following year. This robust pattern drops precipitously for lanes with fewer than 6 weeks of activity, underscoring the increased uncertainty and risk associated with infrequently used lanes.

Figure 8: Probability That a Lane Repeats Based on the Number of Weeks Active in Current Year



Figures 9 and 10 reveal how lane activity duration correlates with volume and cost per load (CPL) changes across all shippers and years. Figure 9 shows a significant stabilization in volume variability after about ten weeks of consistent lane activity, while CPL remains relatively stable regardless of activity duration. This indicates that consistent lane use minimally stabilizes pricing but provides a predictable basis for anticipating volume change in the following year. Figure 10 confirms these findings with absolute percentages, highlighting the benefits of using frequency-based strategies for more accurate and stable budgeting. These insights suggest that regular lane activity is key to enhancing future predictability. This stability in CPL suggests that lanes with sustained activity are slightly less susceptible to the erratic pricing often seen in less consistent lanes, providing a more stable basis for budgeting.

Figure 9: Percent Volume and CPL Change for Next Year Lane Behavior for All Shippers in All Years

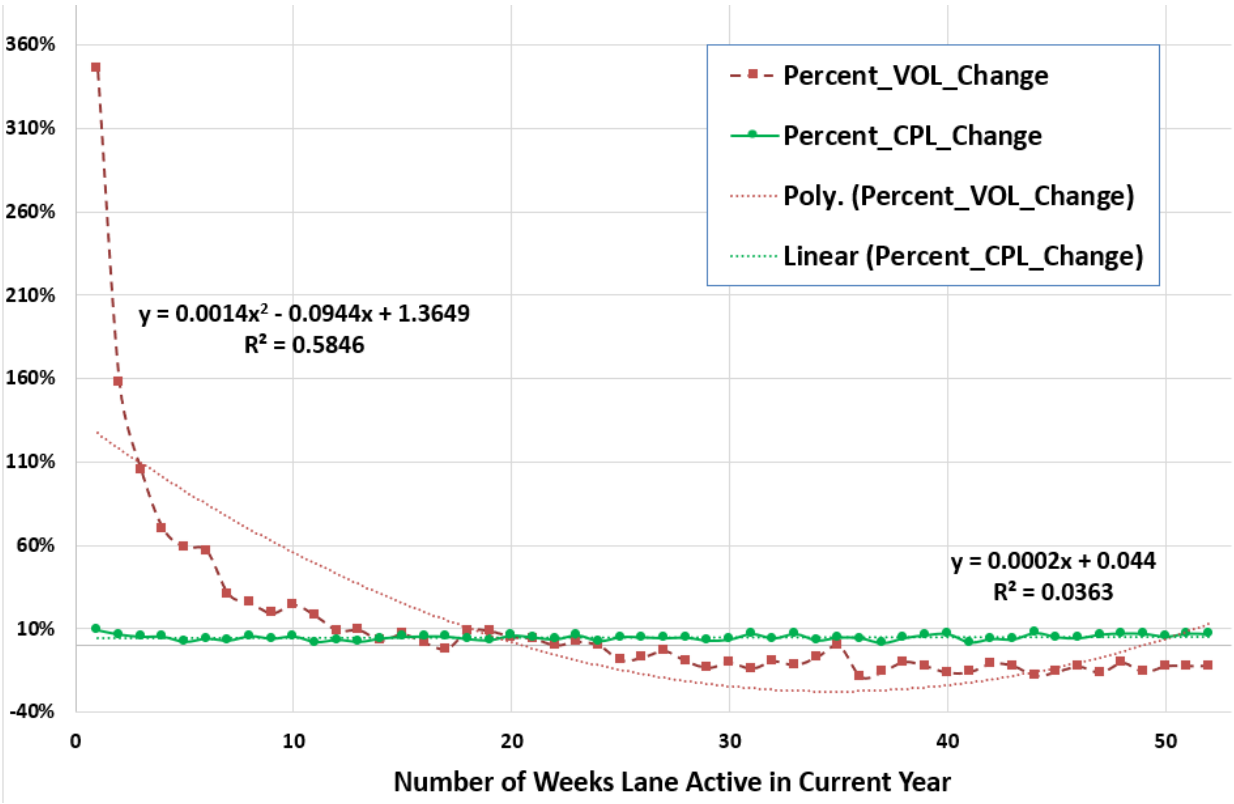
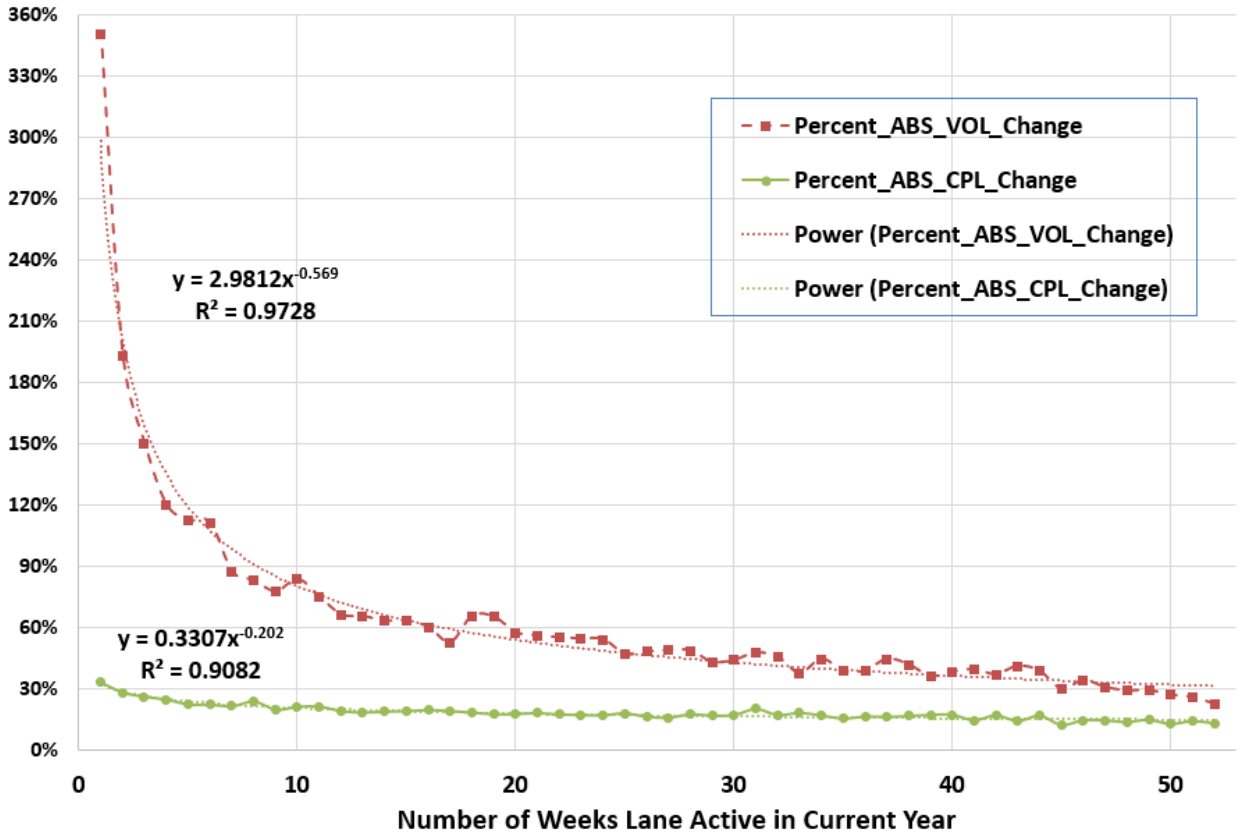


Figure 10: Percent Absolute Volume and CPL Change for Next Year Lane Behavior for All Shippers in All Years



The findings from this analysis informed our discussion on the necessity of incorporating lane consistency into budget forecasting. It is evident from Figure 5 and Figure 8 that lanes with higher volume and consistent utilization week-over-week are more predictable and, hence, should be the focus for budget planning improvements. By understanding these patterns shippers can adjust their budgeting strategies to mitigate the impact of volume and cost volatility and to enhance the accuracy of their financial projections.

In our exploration of lane activity consistency, we found a similar pattern in lane intensity between the volume of loads in the current year and the ensuing year's lane behavior. The number of weeks a lane is active within a year serves as a measure of consistency, whereas the volume of loads demonstrates a measure of lane intensity. As depicted in Figure 8, lanes with consistent weekly activity

(12 weeks or more) demonstrate a high probability (73% to 99%) of recurring utilization in the subsequent year. In Figure 5 we see that lanes with more than 14 loads have a more than 70% probability of repeating the following year. With an intensity of more than 14 loads and an activity of more than 12 weeks, there is a high probability that the lane will repeat the following year. This consistency diminishes drastically for lanes with less than 5 weeks of activity, and with a volume of less than 6 loads which indicates higher unpredictability and thus poses greater risk in budget planning.

4.4 Budget Planning Framework for Full Truckload Transportation

Analysis of shippers' spending patterns showed clear trends in unplanned expenditures, leading us to develop a budgeting framework that leverages the predictability of high-volume and consistent lanes. This framework necessitates that shippers individually assess their high consistency lanes based on the previous year's lane data. We propose an 80% consistency proxy for high volume lanes—defined as those with over 100 loads and active for more than 12 weeks annually—and 20% for low consistency lanes.

The framework comprises of several key components. For detailed calculations of the budget ranges tailored to each shipper category based on their specific unplanned spend profiles, see Item 1b in Appendix B. This framework is also illustrated in Figure 11, which details the budgeting process:

1. **RFP Budget Calculation**: Calculates the total expected spend from the RFP, factoring in contracted rates and expected volumes.

2. **Shipper Category:** Categorizes shippers based on their average annual spend, influencing subsequent budgetary calculations.

3. **Budget Ranges:** Divides the budget into upper and lower ranges to accommodate variations in unplanned spend and lane consistency.

4. **Unplanned Spend:** Multiplies the RFP planned budget amount by the unplanned average percentage, and then either adding or subtracting the RFP planned budget amount by the unplanned standard deviation (stdev) percentage.

5. **High Consistency:** Multiplies the RFP planned budget amount by a shipper's individual high-consistency lane-level percentage, plus the RFP planned budget amount by the stdev percentage of a shipper's individual high consistency lane level information.

6. **Low Consistency:** Multiplies the RFP planned budget amount by a shipper's individual low-consistency lane-level percentage, plus the RFP planned budget amount by the stdev percentage of a shipper's individual low consistency lane level information.

7. **Calculating the Ranges**: Identified the upper and lower ranges of the budget. The upper range unplanned spend should be added to the upper range high consistency spend and then added to the upper range low consistency spend and summed. The same should be done for the lower range. The estimated budget range is the average of the upper and lower range.

Figure 11: Flowchart for Shipper RFP Budgeting Formula

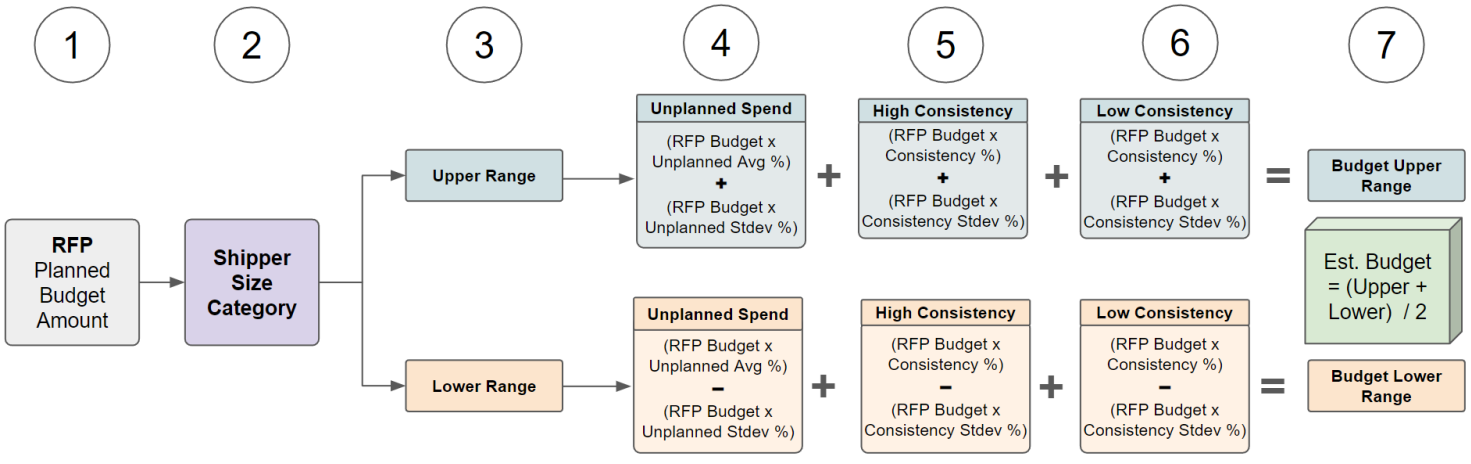


Figure 12 demonstrates an example of this framework; we consider a hypothetical shipper categorized under Category A with a planned annual RFP budget of $52M and an actual spend of $87.3M. Using the

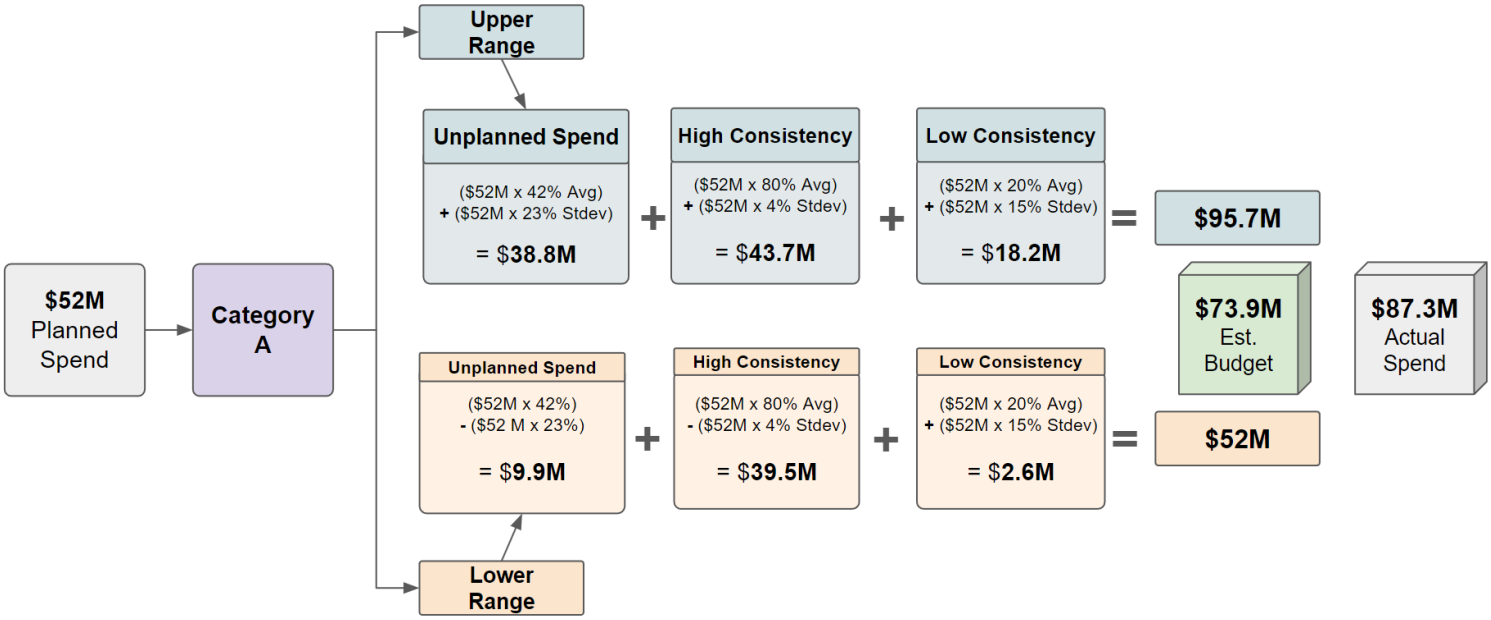
unplanned spend percentages from Table 3, along with high and low consistency proxies, we calculate both the upper and lower budget ranges. The illustrative calculation in Figure 12 demonstrates that the shipper's actual expenditure of approximately $87.3M falls within the computed range of $52M to $95.7M, validating the effectiveness of our model.

This framework serves as a guide for shippers to refine their budgets based on a thorough understanding of their operational dynamics and spending patterns. Our comprehensive analysis in 2022, detailed in Table 1A of Appendix A, assessed the total annual spending of 13 shippers against the budget ranges predicted by our model. The results demonstrated that 6 out of the 13 shippers, or 46%, had budgets that fell within the predicted range. Additionally for 3 out of the 13 shippers our range was under their actual spend by 2-3%, excluding an extreme outlier from Category C which exceeded our predicted upper range by 927% and was therefore considered outside typical predictive assessments. Conversely, 4 out of the 13 shippers had smaller annual spend than our lower range by 14-15%. Notably, all shippers in Category B precisely fell within the budget ranges predicted by our model. These findings collectively affirm that our model accurately predicts budgetary outcomes with a 69% precision rate and a tolerance range of 3%. This high level of accuracy highlights the effectiveness of the budgeting framework when tailored to specific shipper categories and their distinct operational characteristics.

Table 3: Calculated Unplanned Spend Percentages for Each Shipper Category

Shipper Category	Average Unplanned Spend Percentage	Standard Deviation of Unplanned Spend Percentage
A ($60M - $160M)	42%	23%
B ($25M - $59M)	38%	21%
C ($5M - $24M)	48%	38%

Figure 12: Example Shipper RFP Budgeting Event Showing Formula Works in Practice



By integrating both historical data and predictive analytics, this budgeting framework enhances the precision of financial planning in the TL sector, accommodating both planned and unplanned expenses.

5 Conclusions and Recommendations

The full truckload (TL) sector, with a 2022 valuation of approximately $404 billion, continues to struggle with significant budget overruns, presenting a critical challenge for shippers (Zimmerman et al., 2023). Analysis of 13 shippers across a span of six years reveals a consistent trend of over-budgeting, with overruns ranging from a modest 6% to a remarkable 180%. These findings underscore the complexity of freight budgeting and highlight the imperative for a paradigm shift in budgetary practices.

This study has shown that traditional budgeting methods, heavily reliant on the traditional idea of an annual RFP and routing guides, are inadequate. The frequency of ghost lanes coupled with substantial unplanned spot market expenditures, demands a new way of approaching procurement strategies.

Our budgeting framework has demonstrated significant predictive strength across various shipper categories. This model addresses the critical challenge of budget overruns by providing a systematic approach that accommodates both planned and unplanned expenses more effectively. To enhance the application of the proposed budgeting framework, it is recommended that shippers across various categories tailor their budgeting strategies according to unique spending patterns and lane consistency data observed in their operations. For example, Category A shippers, managing larger budgets, should integrate advanced predictive analytics to closely monitor high-volume lanes and adjust their financial plans based on real-time market conditions. Notably, 100% of Category B shippers saw their actual expenditures align perfectly with our predictions, underscoring the model's robustness in scenarios with mid-sized shippers. While Category C shippers, with more constrained resources, might focus on more conservative budgeting tactics to better accommodate frequent, unplanned expenditures typically observed in their spending patterns. The implementation of this budgeting framework could shift in how shippers approach financial planning towards a more dynamic and data-driven approach.

5.1 Key Results

Our key findings suggest a disconnect between traditional budgeting methods and the realities of freight transport budgeting. A strategy to address this involves reducing the occurrence of ghost lanes, accounting for spot market usage, and utilizing previous years' data on lane consistency to formulate a more accurate budget. Our empirical evaluation of the budgeting framework across thirteen shippers demonstrated its efficacy. Analysis of annual budgets against our model's predictions shows that the framework accurately forecasted the budgetary outcomes within a 3% margin for 69% of the cases. This high precision underscores the framework's utility in enhancing financial predictability in the freight sector, particularly through its ability to accommodate both planned and unplanned expenditures effectively.

An analysis on lane behavior elucidates the value of lane consistency as an important metric for budget planning. The pattern established within these data—lanes active for more than 14 weeks having an 87% probability of repetition—presents an opportunity for shippers to refine their budgeting strategies. By leveraging this pattern, shippers can better prepare for cost and volume variances, hence enhancing financial projection accuracy.

5.2 Areas for Future Research and Limitations

Given these insights, future research should aim to develop advanced tools that integrate lane-level consistency and shipment frequency into the budgeting equation. There is potential in examining increased use of direct-to-spot procurement and the benefits of simplifying the RFP process, potentially through the reduction of ghost lanes. Future research could explore the long-term impacts of implementing our proposed budgeting framework across diverse shipping environments and market conditions. It would also be fruitful to compare the outcomes of shippers who adopt the new budgeting framework versus those who continue with traditional methods, providing a broader empirical basis for

the framework's efficacy. We advocate for a reexamination of procurement practices, particularly for smaller shippers, to reduce the prevalence of ghosted lanes and to introduce more frequent and smaller-scale RFPs. This shift could also allow for low-volume, inconsistent lanes to be strategically directed to the spot market. It is important to note that our analysis is limited by its reliance on historical data as a proxy for actual budgets, which might not fully capture the dynamic nature of freight costs and operational changes. This methodological constraint underscores the need for real-time data integration and predictive analytics in future budgeting tools to enhance accuracy and reliability.

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7 APPENDIX A

Table 1A: Evaluation of Shipper 2022 Budgets Using the Strategic Budgeting Framework

Shipper 001			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$22,266,510	$28,775,182	$11,989,659	**$63,031,352**	**$48,643,761**	**$ 64,318,473**
$34,256,170	***A***	Lower Range	$6,508,672	$26,034,689	$1,712,808	**$34,256,170**		

Shipper 002			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$129,366,134	$167,180,850	$69,658,688	**$366,205,672**	**$282,615,247**	**$243,418,747**
$199,024,822	***A***	Lower Range	$37,814,716	$151,258,865	$9,951,241	**$199,024,822**		

Shipper 003			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$68,471,592	$88,486,365	$36,869,319	**$193,827,276**	**$149,584,094**	**$ 91,033,309**
$105,340,911	***A***	Lower Range	$20,014,773	$80,059,092	$5,267,046	**$105,340,911**		

Shipper 004			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$36,369,940	$47,001,154	$19,583,814	**$102,954,908**	**$79,454,331**	**$ 54,705,479**
$55,953,754	***A***	Lower Range	$10,631,213	$42,524,853	$2,797,688	**$55,953,754**		

Shipper 005			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$53,024,543	$71,839,703	$29,933,210	**$154,797,456**	**$119,732,839**	**$101,878,630**
$85,523,456	***B***	Lower Range	$15,394,222	$64,997,827	$4,276,173	**$84,668,222**		

Shipper 006			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$31,361,964	$42,490,404	$17,704,335	**$91,556,703**	**$70,817,339**	**$ 54,320,480**
$50,583,814	***B***	Lower Range	$9,105,086	$38,443,698	$2,529,191	**$50,077,976**		

Shipper 007			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$10,543,196	$14,284,331	$5,951,804	**$30,779,331**	**$23,807,218**	**$ 29,621,422**
$17,005,155	***B***	Lower Range	$3,060,928	$12,923,918	$850,258	**$16,835,104**		

Shipper 008			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$10,834,541	$14,679,055	$6,116,273	**$31,629,869**	**$24,465,092**	**$ 21,525,016**
$17,475,066	***B***	Lower Range	$3,145,512	$13,281,050	$873,753	**$17,300,315**		

Shipper 009			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$9,422,895	$9,312,038	$3,880,016	**$22,614,949**	**$16,406,924**	**$ 23,832,842**
$11,085,759	***C***	Lower Range	$1,219,434	$8,425,177	$554,288	**$10,198,899**		

Shipper 010			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$12,657,031	$12,508,125	$5,211,719	**$30,376,874**	**$22,038,125**	**$ 31,303,495**
$14,890,625	***C***	Lower Range	$1,637,969	$11,316,875	$744,531	**$13,699,375**		

Shipper 011			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$20,914,393	$20,668,342	$8,611,809	**$50,194,544**	**$36,415,649**	**$ 19,241,131**
$24,605,169	***C***	Lower Range	$2,706,569	$18,699,928	$1,230,258	**$22,636,755**		

Shipper 012			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$489,771	$484,009	$201,670	**$1,175,451**	**$852,778**	**$ 10,894,839**
$576,201	***C***	Lower Range	$63,382	$437,913	$28,810	**$530,105**		

Shipper 013			Unplanned Spend	High Consistency Spend	Low Consistency Spend	Budget Range	Est. Budget	Actual Spend
RFP Planned Budget	Shipper Size Category	Upper Range	$8,722,424	$8,619,807	$3,591,586	**$20,933,817**	**$15,187,279**	**$ 13,208,509**
$10,261,675	***C***	Lower Range	$1,128,784	$7,798,873	$513,084	**$9,440,741**		

Note: The colors in Actual Spend are shades of green when our model range predicts within the actual spend and shades of red when the model predicts a budget range below the actual spend.

8 APPENDIX B

Item 1b: Specific Budget Range Calculation Formulas for Different Shipper Categories

Let:

B	RFP planned budget
S	Shipper specific category
U_{avg}^{S}	Average of unplanned spend percentage
U_{stdv}^{S}	Standard deviation of unplanned spend percentage
H_{perc}	Percent of lanes over 100 loads and active for more than 12 weeks annually
H_{stdv}	Standard deviation percent of lanes over 100 loads and active for more than 12 weeks annually
L_{perc}	Percent of lanes less than 100 loads and active for less than 12 weeks annually
L_{stdv}	Standard deviation percent of lanes less than 100 loads and active for less than 12 weeks annually

Formula:

$$Upper\ Budget\ Range = \left(B * U_{avg}^{S} + B * U_{stdv}^{S}\right) + \left(B * H_{perc} + B * H_{stdv}\right) + \left(B * L_{perc} + B * L_{stdv}\right)$$

$$Lower\ Budget\ Range = \left(B * U_{avg}^{S} - B * U_{stdv}^{S}\right) + \left(B * H_{perc} - B * H_{stdv}\right) + \left(B * L_{perc} - B * L_{stdv}\right)$$