MIT Global Supply Chain and Logistics Excellence Network

MIT GLOBAL SCALE NETWORK

WORKING PAPER

TITLE:

The hidden costs of not-so-friendly ghost lanes

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DATE:

July 4, 2022

NUMBER:

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ABSTRACT:

Firms' (shippers') procurement of truckload (TL) transportation services is a costly, time-intensive process. The result of these months-long procurement events is typically thousands of contracts between the shipper and transportation service providers (carriers) covering each of the shipper's lanes (origin-destination pairs) over which it distributes products. Due to TL supply and demand uncertainty, shippers often adopt a coverage strategy to ensure contracted capacity is secured on combinations of lanes on which demand is expected. However, this strategy leads to unnecessary costs and inefficiencies.We find that a large percentage of shippers' lanes never end up being utilized. We refer to contracted lanes on which no business materializes as ghost lanes. In this study, we characterize ghost lanes to help shippers identify which lanes need not be contracted in the first place to reduce existing startup costs. When none of the expected business on ghost lanes materializes, this disrupts carriers' network balance and operating efficiencies and impacts service levels to other customers. We empirically demonstrate how the disruptions from ghost lanes from a shipper in one year factor into carriers' performance and pricing decisions the following year. Moreover, for the lanes that are characteristically ghost lanes but that do materialize, carrier rejection rates are high as are contract prices relative to spot market prices - in other words, shippers are overpaying anyway. We conclude by recommending that firms reconsider their coverage approach to TL transportation procurement by excluding lanes with high probability of becoming ghost lanes (in particular, new lanes) from the traditional annual procurement process.

KEYWORDS:

Freight procurement, truckload, empirical research

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The hidden costs of not-so-friendly ghost lanes

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Firms' (shippers') procurement of truckload (TL) transportation services is a costly, time-intensive process. The result of these months-long procurement events is typically thousands of contracts between the shipper and transportation service providers (carriers) covering each of the shipper's lanes (origin-destination pairs) over which it distributes products. Due to TL supply and demand uncertainty, shippers often adopt a coverage strategy to ensure contracted capacity is secured on combinations of lanes on which demand is expected. However, this strategy leads to unnecessary costs and inefficiencies. We find that a large percentage of shippers' lanes never end up being utilized. We refer to contracted lanes on which no business materializes as ghost lanes. In this study, we characterize ghost lanes to help shippers identify which lanes need not be contracted in the first place to reduce existing startup costs. When none of the expected business on ghost lanes materializes, this disrupts carriers' network balance and operating efficiencies and impacts service levels to other customers. We empirically demonstrate how the disruptions from ghost lanes from a shipper in one year factor into carriers' performance and pricing decisions the following year. Moreover, for the lanes that are characteristically ghost lanes but that do materialize, carrier rejection rates are high as are contract prices relative to spot market prices - in other words, shippers are overpaying anyway. We conclude by recommending that firms reconsider their coverage approach to TL transportation procurement by excluding lanes with high probability of becoming ghost lanes (in particular, new lanes) from the traditional annual procurement process.

Key words: Freight Procurement, Truckload, Empirical Research

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1. Introduction

At $689 billion in revenue in 2020 (AT Kearney 2020), trucking services make up a major segment of firms' total logistics costs. In addition, trucks move about 70% of freight in the US (AT Kearney 2020). Due to its importance, much attention has been paid to the procurement of truckload (TL) transportation services. However, both firms' (shippers') demand and service providers' (carriers') supply are highly uncertain. This uncertainty can lead firms exposed to a volatile spot market to source needed capacity. Firms establish long-term transportation contracts to cover all anticipated demand during a single annual procurement event during the year. As such, if new business materializes that has not been contracted, the firm must rely on ad hoc spot market interactions.

To reduce this risk of spot market exposure, shippers adopt a "coverage" procurement strategy. That is, they establish contracts with suppliers on all anticipated segments of their networks (i.e., origin-destination demand pairs called lanes) despite the uncertainty of whether the associated demand will ultimately materialize over the contract timeframe on those lanes. In this way, they expect their demand will still be served by a contracted provider of choice if it materializes. We describe this strategy in further detail in Section 3.

In addition to the potential risk mitigation benefits of a coverage strategy, firms use the strategy to establish secure and fast payment processes upfront for demand if it should occur. There are procurement costs incurred upfront (e.g., search and negotiation) and administrative costs of manually loading service, supplier, and pricing information into transportation management systems (TMS) that automate load tendering operational processes during contract execution.

Firms considering a coverage strategy weigh the tradeoffs between known costs upfront versus potential costs later on. The cost to procure transportation services on lanes which may never be used may be less than the future costs if demand materializes to find a provider, negotiate a price, establish communication and payment channels later during the execution stage and a potential spot premium the firm may have to pay over the contract price that would have been in place.

Despite the anticipated benefits of a coverage strategy, its effectiveness has yet to be studied. In particular, we consider whether the coverage strategy has the intended benefits of keeping the firm out of the spot market, and whether there are unintended additional costs of the coverage strategy that firms are not considering in the "now vs. later" tradeoff.

For example, there may be significant performance and cost disadvantages to coverage. The annual transportation procurement process is lengthy and costly to shippers and carriers alike. Artificially inflating the procurement process by including potentially unnecessary lanes increases the resources required to run the procurement event.

Moreover, a coverage strategy disrupts suppliers. Carriers plan to allocate capacity to serve contracted demand. Network imbalances are created when the demand does not materialize. We call lanes on which no volume materializes for the contracted carrier ghost lanes. Ghost lanes can lead to operational inefficiencies for carriers, which in turn may lead these suppliers to deprioritize the shipper's business or require higher prices to serve that business in the future.

The practice of coverage, the resulting ghost lanes and their implications on costs and service levels have been largely overlooked by both transportation professionals and the literature.

Our study makes four main contributions. First, we empirically demonstrate shippers' ghosting tendencies and frequency. Second, we identify characteristics of ghost lanes to help shippers and carriers identify them before they are contracted. Third, we demonstrate how ghosting from a shipper contributes to carriers' performance and pricing in the future. Finally, we contribute to the procurement literature by empirically exhibiting that a coverage strategy is may not be an effective method to reduce uncertainty risks.

The remainder of this paper is organized as follows. In Section 2 we describe the background of the relevant transportation processes. In Section 3 we explain the motivation for shippers' strategic choice to implement a coverage strategy and resulting ghost lanes. In Section 4 we define the research questions motivated by the problems associated with ghosting. In Section 5 we summarize and explore the empirical data used to develop our empirical models, which are described in Section 6. In Section 7 we discuss our model results. We discuss the effectiveness of the coverage strategy in Section 8. The study's implications and managerial implications are discussed in Sections 9, and the limitations of this research and potential extensions are discussed in Section 10.

2. Research Context Background: two stages of truckload transportation

When a shipper needs to move goods from point to point it has a number of over-the-road transportation service options. These options lie on a spectrum of relationship forms between the shipper and carrier.

On one end of the spectrum is the in-house private fleet. With enough network scope and volume, some firms choose to vertically integrate the TL transportation function. However, despite the advanced levels of control and service afforded by these private fleets, they can be inefficient with low truck utilization rates (i.e., high percentage of miles driven empty, or not loaded) (Baker and Hubbard 2003). As a result, TL transportation services are often outsourced.

The first of the two outsourced TL options, sitting on the other end of the spectrum is the purely transactional option, or "spot" market. In this case, a shipper selects a carrier to haul individual loads as they arise. The price is determined at that time and only applies to the single load.

The middle of the spectrum is comprised of the other outsourced, or for-hire, option: the contract. In general, the price for contracted freight is negotiated upfront and applies to all loads that materialize on an origin-destination pair (lane) for a period of time. The contract relationship can take many forms. However, the most common form is the one-year, fixed-price contract.

Most shippers utilize a combination of these options. For example, the spot option is often used to fill in gaps - either when demand exceeds contracted capacity, or when private fleet trucks need to be repositioned. About 10-20% of for-hire freight goes to the spot market (Caplice 2007). While, this percentage varies widely depending on the market conditions, the overwhelming majority of for-hire loads move under contract.

The challenges introduced by ghost lanes that we describe above and highlighted in the literature (see e.g., Scott et al. (2016, 2020), Acocella et al. (2020)) can be best understood by considering the two distinct stages of outsourced TL transportation: (1) strategic procurement, and (2) operational load tendering and acceptance.

2.1. First stage: strategic procurement and non-binding contract

During the strategic TL procurement process, a shipper conducts a reverse auction (for details, see Caplice and Sheffi (2003) and Caplice (2007)). The shipper forecasts the demand for truckload capacity it expects to have on each of its origin-destination pairs. It invites carriers to participate in the auction by sending them requests for proposals (RFPs). Carriers respond to these RFPs by submitting bid prices for each lane they are interested in serving.

Carriers' bid prices for lanes depend on a number of factors. How they decide on the price, often called the bid generation problem, has been the topic of many studies (see e.g., Song and Regan (2005), Lee et al. (2007)). The carrier seeks to maximize profit (Cachon and Lariviere 1999) by factoring characteristics of the lane and shipper such as expected demand on the lane, how well it helps balance its existing network of business, and how important that shipper is to work with, for example. Essentially balancing both long- and short-term demand from multiple customers (shippers) (Adelman and Mersereau 2013).

Shippers collect carriers' bid prices, analyze them, and choose the best carrier to contract with on each of its many lanes. This is called the carrier assignment problem in the literature (Caplice and Sheffi 2005, Guo et al. 2006). The shipper's goal is to get carriers to bid at their reservation price (i.e., the lowest price they are willing to accept to serve the lane)(Lindsey and Mahmassani 2015). The shipper then chooses the lowest bidding carrier subject to service level and reputation constraints (Lu 2003, Rekik and Mellouli 2012) and lane- and/or network-level cost objectives. The process to comb through thousands of bids and find the optimal assignment of carriers to lanes takes time - usually months - of shipper manpower. The result is a contract with one or more carrier on each lane. For a review of the TL procurement process, see Basu et al. (2015).

The contracts are binding in price but non-binding in volume offered by the shipper or accepted by the carrier (Caplice 2007). That is, volume that materializes on the lane tendered to the contracted carrier must be hauled at the contract price. However, there is no legally enforceable penalty for shippers if they tender less (or more) than the expected volume and when volume does not appear, the carrier does not get paid. There is also no commitment from the carrier to accept the contracted volume that is tendered to it. This is the second, operational stage of truckload procurement.

2.2. Truckload contracts

As a result of the business volume and associated costs of TL services, firms spend a great deal of resources to procure them (Moore Jr et al. 1991, Zsidisin et al. 2007). The outcome of the procurement process is a contract with a carrier on each lane. The contracts are defined by a (typically) fixed price, an expected volume (i.e., number of loads the shipper forecasts on the lane), and carrier service level expectations over the contract terms (traditionally one or more years (Caplice and Sheffi 2003)).

A unique aspect of these truckload contracts - and a main driver of cost escalations for shippers (Caplice 2007, Scott et al. 2016, Acocella et al. 2020) - is that they are non-binding in two ways. First, in the volume of business offered by the shipper to the carrier, and second in the capacity provided by the carrier. These are sometimes called relational contracts (Baker et al. 2002). At the time of procurement, it is difficult for shippers to forecast the precise time and location a truck will be required across its network of usually thousands of lanes for the next year. At the same time, carriers serve many shipper customers at a given time. Compounding demand uncertainties from each of them makes capacity availability at the time and location needed all the time near impossible. Neither party wants to be penalized for factors out of their control. Thus, the contracts are flexible in volume offered and capacity provided. Both shippers and carriers do track and monitor adherence of the other to the original stated volumes and capacities. Rather than measured for contract compliance, they are used as another level of service indicators, similar to on-time delivery.

To account for contracted carrier rejections of loads tendered to them, shippers establish backup carriers on each lane. These are typically carriers that have lost the bid but expressed ability to serve the lane. There is no contract in place with these carriers. Shippers construct a routing guide of these backup carriers and tender a load to them when it is rejected by the primary contracted carriers. Shippers also rely on the spot market typically as an ad hoc alternative to contracted carriers. In this case, shippers consult a load board where carriers post available capacity and pricing for one-off moves or work with a broker (a third-party intermediary that matches shippers with carriers).

Contracts play an important role in buyer and supplier interactions (Klein et al. 1978), such as defining prices (Crocker and Masten 1991) and specifications of the good or service to exchange (Argyres et al. 2007). Despite the uncertainty in business and capacity under the TL contract, both shippers and carriers benefit from them - highlighted by the fact that 80-90% of loads are accepted by contracted carriers (Caplice 2007, Acocella et al. 2020).This also depends on the overall market conditions, discussed in Scott et al. (2016), Acocella et al. (2020), and in Section 2.3. Shippers use contracts to set transportation budgets based on expected volume on each lane and the associated contracted prices. Moreover, the procurement process involves vetting carriers based on historical performance, incumbency, technological sophistication, etc., and establishing expectations. Scott et al. (2020) demonstrate that contracts improve supplier performance in the TL context. Thus, shippers prefer to work with contracted carriers rather than alternative backup or spot carriers.

In addition to expected performance benefits of contracted carriers, there are cost implications to relying on backup and spot carriers. Backup carriers can cost shippers upwards of 18% more than the contract price, and spot market carriers can result in 35% premiums over the contract rate (Aemireddy and Yuan 2019). To minimize reliance on high-priced and volatile spot options, shippers try to establish contract prices with carriers on each lane in their networks.

Carriers similarly use contracted business to anchor their operations. They build point-to-point movements with the goal to establish a balanced network with high utilization rates (minimal miles driven empty and unpaid). This concept of economies of scope in TL carrier decisions has been explored in Caplice and Sheffi (2003). Moreover, having established contract prices reduces the total transaction costs incurred by negotiating for each load individually (Masten 2010). Carriers do so by planning their capacity around contracted business. Thus, they value (predictable) future business from the shipper (Scott et al. 2020).

2.3. Second stage: contract execution and deviations from the plan

In addition to the cost escalations shippers face when relying on backup and spot market carriers, supply and demand imbalances cause freight price fluctuations. Periods in which capacity is constrained are called tight markets. Shippers' demand for trucks exceeds carriers' capacity. One snapshot measurement of tight markets is the load-to-truck ratio reported by market intelligence company and spot market load board operator, DAT Freight & Analytics. It measures the number of TL loads that shippers post in need of a truck on DAT's load board relative to the number of available trucks posted by carriers. For example, during an extremely tight market of January 2022, DAT's national load-to-truck ratio reached over 10 (DAT 2022). On the other hand, during a soft market, overcapacity pushes prices down and can force - especially smaller carriers - out of the market. These market dynamics and their effects on shipper and carrier behaviors have been explored in Acocella et al. (2020), Pickett (2018), Scott et al. (2016).

Many challenges arise because the operational load tendering and acceptance processes do not happen according to the strategic plan. A small but growing set of empirical research addresses the inconsistencies between the first and second stages. More specifically, the performance outcome of the contract relating to the supplier's behaviors (i.e, carrier acceptance). Zsidisin et al. (2007) study how the relationships between shippers and contracted carriers contribute to acceptance rates. Scott et al. (2016) quantify the operational and economic drivers of both primary contracted carriers and backup carriers. Acocella et al. (2020) explicitly consider how freight market conditions and long-term shipper-carrier relationships contribute to carrier acceptance. Scott et al. (2020) show that explicit TL contracts improve exchange performance (measured as carrier acceptance rates). But that the performance benefits are reduced when the outside market is more attractive to suppliers - that is, when spot market prices rise. Moreover, other studies have explored freight and lane characteristics, including shippers' load tendering patterns, that contribute to carriers' acceptance decisions (e.g., Harding (2005), Kim (2013), Amiryan and Bhattacharjee (2015) and Aemireddy and Yuan (2019)).

However, while there is a large body of literature on the costly procurement process to explicitly construct contracts, very little empirical research has studied performance outcomes, particularly related to the buyer's decisions (Masten 1993, Anderson and Dekker 2005, Schepker et al. 2014). Ours is the first to our knowledge that empirically explores the shipper's (buyer's) decisions to stick to the expectations of the TL contract rather than the carrier (supplier). There are a number of ways the shipper can defect as it relates to the non-binding volume commitments. In an ideal world, the shipper offers the expected volume on the lane with a consistent, predictable pattern. However, the shipper may end up having much more than the expected demand, or surge volume during peak periods it did not expect or did not communicate to the contracted carrier. Alternatively, less volume than expected may materialize. And, as an extreme, we have ghost lanes, where none of the expected volume is tendered to the contracted carrier.

These scenarios are difficult for the carrier to respond to and may drive up its inefficiencies and costs. In this research, we address these ghost lanes. We demonstrate the pervasiveness of ghosting in TL shipper-carrier interactions and how it plays into shippers' and carriers' costs.

Moreover, the literature has put a growing emphasis on empirical research that captures the behaviors and decisions of real firms. Ours is one of a few to study repeated decisions of hundreds of suppliers (carriers) with dozens of customers (shippers) over a multi-year timeframe. Given our expansive datasets, we can generalize from our empirical models and offer contributions to previous work on procurement strategy - specifically the effectiveness of the coverage strategy which firms use to make tradeoffs between costs now versus later: administrative and procedural costs during the strategic stage versus later at the execution stage.

3. Coverage strategy and ghost lanes

The coverage strategy is a shipper's strategic choice at the strategic procurement stage resulting from the uncertainty in the execution stage. It has two intended effects: reduce shippers' exposure to the spot market, and balance the tradeoffs between incurring administrative costs upfront rather than later. These administrative costs include searching for and vetting carriers for each lane, loading price and carrier information into the TMS's, establishing the communication contact points, communicating freight requirements to the carrier (e.g., loading/unloading information, appointment expectations, pickup and dropoff facility specifications, etc.).

The coverage strategy can take a number of forms. Shippers aim to have contracted carrier acceptance on all freight that may materialize. Therefore, they often establish contracts with carriers for lanes on which new demand is uncertain but expected between the current and next planned procurement cycle. Rather than relying on spot market capacity or having to run an additional bidding later on for individual lanes when demand does appear, shippers often include these new lanes in their main annual procurement events.

Another way shippers implement a coverage strategy is in the granularity in which lanes are defined. A TL lane is defined from point A to point B. However, the contract may define either of those points as the exact pick-up and drop-off location warehouse addresses or at a less granular region level. For example, location A could be a greater city area in which the shipper has multiple facilities. It may aggregate the demand from those facilities to their respective destinations if each of these separate lanes produce low volumes. In this way, the carrier that is contracted for this less granular lane can accumulate more substantial volume (Caplice and Sheffi 2005). This may be more attractive to a carrier intending to bid on the lane than multiple, low-, perhaps erratic, volume lanes.

Whichever the method, a shipper's coverage procurement strategy aims to ensure its demand is covered by a contract to reduce its risk of relying on capacity on the spot market, characterized by price volatility and often poor or uncertain service. However, shippers' procurement processes are costly already (see Section 2). Reducing the required time, resources, and complexity of the process could have major benefit. Moreover, it is unclear whether the coverage strategy has unintended future cost or carrier performance ramifications.

We focus on one of the disadvantages of the non-binding truckload contract and resulting coverage strategy: ghost lanes. These are lanes on which a shipper has established a contract for some expected volume with a carrier but no volume materializes during the contract period.

The problem introduced by ghost lanes is twofold. First, carriers have planned for the contracted business and allocated capacity available for it. They use this pre-determined information to build efficient business (Powell 1996, Tjokroamidjojo et al. 2006, Zolfagharinia and Haughton 2014). When the business does not come, the carrier faces opportunity costs for having planned for that business and must rebalance its existing network. Often that means repositioning its capacity and driving empty and unpaid. One of a carrier's main goals is to minimize these "deadhead" moves. Despite the potential disruptions ghosting can cause the contracted carrier's network balance, there are no explicit or legally enforceable penalties to the shipper for doing so.

The second issue brought about by ghost lanes pertains to the shipper. Transportation procurement is a resource-intensive process and can take companies 3-6 months to execute (Caplice and Sheffi 2005). Including unnecessary lanes in the process is inefficient and costly for the shipper. Moreover, while there may not be contractually enforceable penalties for ghosting, there may be future repercussions from the carrier. For example, ghosting may impact carriers' future willingness to accept business from the shipper or their pricing of contracts less competitively in the future.

Shippers may ghost contracted carriers for a number of reasons. The first relates to demand forecasting difficulty. The shipper may have a new customer drop-off location or have opened a new warehouse but does not know when orders or operations will begin. In this case, uncertainty in demand has resulted in ghost lanes; the shipper is not fully to blame for ghosting in this case.

However, the shipper can be at fault for another reason of ghosting. Shippers regularly contract with more than one carrier on a single lane. This will happen for high-volume lanes and sometimes for lanes that have irregular and difficult to predict surge demand. The shipper splits the volume between multiple carriers to even out the demand each individual carrier sees. However, if a shipper contracts multiple carriers on a lane but does not offer any of the volume that does materialize to at least one carrier, that carrier experiences the lane as a ghost lane. In this case, which we call a partial ghost lane, the shipper had business but chose not to offer it to a contracted carrier. Both of these causes of ghost lanes speak to a coverage strategy that is common with shippers.

4. Research Questions and Hypotheses

As discussed in the preceding sections, the ghost lane phenomenon is an outcome of shippers' coverage strategies and a unique result of the two-sided non-binding nature of TL freight contracts. It has yet to be fully explored in the literature. We formalize two research questions to empirically uncover the extent and impact of shippers' ghosting practices.

RQ1: What characteristics of a lane can shippers and carriers use to determine if it will be a ghost lane at the time of strategic procurement?

To address RQ1, we formulate four hypotheses. The first relates to shippers' coverage strategies. Say a new facility is planned to open within the next few months. Shippers often prefer to secure a contract price with a carrier for when the facility opens and the carrier is eventually needed. This may not be communicated to the carrier during the procurement event. If there are delays that push the opening date back, loads on this lane may never materialize and it will become a ghost lane. Thus, we expect new lanes procured in a given year to have a higher likelihood of becoming ghost lanes.

H1a: New lanes - that is, lanes that the shipper has not procured contracted capacity the previous year - are more likely to be ghost lanes.

A similar coverage approach relates to the geographic aggregation or granularity at which the shipper defines the origin and destination of the lane. To reduce the efforts during RFPs - collecting and analyzing bids, selecting winning carriers, and managing the lane price information on many lanes - shippers may aggregate individual low-volume point-to-point locations into geographic regions. This can help accumulate more substantial demand volumes on a single lane rather than several low-volume point-to-point lanes (see Caplice and Sheffi (2005)).

For example, a lane could originate at a specific facility point location and terminate at another specific warehouse location. Or, the shipper may aggregate warehouse locations with others nearby. It would then communicate to a carrier that loads should be expected to originate from multiple facilities across a geographic region defined at the 3-digit zip code level, for example. The set of possible origin/destination granularity levels are summarized in Section 6. Shippers tend to define lanes at the more specific level when they expect more, consistent volume to occur or if they are more important lanes to manage carefully. Thus we have:

H1b: The less granular the origin or destination geographic definition of the lane, the more likely the lane will be a ghost lane.

In the next hypothesis we consider the carrier service type. Firms are more efficient at serving the market based on their service specializations (Penrose 2009). Shippers interact with and utilize asset carriers and brokers, or non-asset carriers, quite differently (Scott et al. 2016, Acocella et al. 2020). Non-asset carriers do not own any trucks but they act as the intermediary between shippers and typically smaller, asset-based carriers and offer value-added services (Deepen et al. 2008). Since they access a large pool of flexible capacity, they are used by shippers for lanes on which demand is uncertain and inconsistent. On the other hand, asset carriers plan optimized service networks and put a higher value on consistency. Thus, we expect brokers to be contracted on lanes with less certain demand:

H1c: Non-asset providers, or brokers, are more likely to be ghosted than asset-based carriers.

Finally, we consider the year - and more specifically, the market condition - in which the lane is procured. When markets are soft and consumer demand is low, the need for capacity is down. This is compared to tight market periods when transportation demand exceeds supply (Scott et al. 2016, Pickett 2018, Acocella et al. 2020). In our dataset, discussed in Section 5, the soft market period occurs during 2015, 2016, 2019 and the tight market period occurs in 2017 and 2018. Our hypothesis is:

H1d: A lane is more likely to become a ghost lane during soft freight market conditions than tight.

Next, we consider the potential impacts that a shipper's ghosting practices have on carrier behavior with our second research question:

RQ2: Do carriers that experience high ghost lane percentage in one year reciprocate with lower freight acceptance rates or higher, less competitive contract prices the following year?

To address RQ2, we formulate two hypotheses. First, fulfillment of service requests is a fundamental need for buyers Cachon and Lariviere (1999). And it is one shippers strive to keep high. However, carriers incur opportunity costs if they plan to allocate capacity for a shipper's lanes but the business does not occur (Powell 1996, Tjokroamidjojo et al. 2006, Zolfagharinia and Haughton 2014). Carriers have limited bargaining power in the relationship. There is little a carrier can do about poorly performing shippers other than behave defensively going forward, for example, and not prioritize the shipper's business. Thus we expect ghosting to impact carriers' future freight acceptance decisions on other lanes:

H2a: A higher percentage of lanes that become ghost lanes from a shipper to a contracted carrier in one year correlates to lower acceptance rates *the following year* from that contracted carrier.

Similar to the reasoning above, a carrier may price a shipper's business higher to overcome the greater potential of opportunity costs due to ghosting the previous year. Carrier's margins are quite low; between 2.4-6% according to American Trucker (Fleet Owner 2018). Large asset carriers have better profit margins than small carriers because they can achieve greater efficiency with their scale (Silverman et al. 1997).) However, a non-asset broker achieves higher profits by hedging the market and setting contract prices higher than what it expects of the spot market. In either case, carriers may have a lower willingness to serve poor performing shippers without a satisfactory potential profit.

H2b: A higher percentage of lanes that become ghost lanes from a shipper to contracted carrier in one year correlate to higher, less competitive contract prices *the following year* from that contracted carrier.

For both of the above hypotheses, we control for a set of fixed effects of the carriers themselves as well as market condition. In addition, we consider attributes of the relationship between the shipper and contracted carrier, as discussed in Section 6.

5. Data summary & exploration

We address our hypotheses by building models of shipper and carrier behavior using three empirical datasets. They represent multiple shippers' procurement and load tendering decisions, as well as contracted carriers' load acceptance decisions over time. These datasets are provided by TMC, a division of C.H. Robinson. While C.H. Robinson is the largest global third-party logistics (3PL) provider (i.e., broker) in the US, TMC is the company's transportation management branch. Rather than provide freight-carrier matching services as a broker does, TMC acts as the shipper's in-house transportation business unit. The shipper determines transportation strategies and goals and TMC implements them and provides transportation expertise. As such, the TMC data represent shippers' internal decisions and strategies and carriers' direct interactions with shippers without an intermediary. The datasets cover both first and second stages of TL transportation procurement. More specifically, the TL, dry van, long-haul segment of each shipper's transportation needs. The general pricing approaches and lack of specialized equipment or processes for this segment allow us to make comparisons and generalizations across the important factors we uncover. This is compared to short-haul, specialized, or less-than-truckload segments. Moreover, dry van shipping is the most common trailer type in the US TL sector.

5.1. Data files

The data range from September 1, 2015 to September 1, 2020 for dozens of shippers across industries, thousands of their (primary) contracted carriers, over transportation networks spanning the continental US. The first dataset, referred to as the Cost Quotes file, represents the outcome of the strategic procurement event (the first stage) for 22 shippers over this timeframe. After data cleaning, down from 89 shippers. We select the 22 shippers with clear identifiable procurement events. Specifically, for each shipper we identify the date of each shipper's procurement event, each lane (origin-destination combination) contracted during that procurement event, the geographic hierarchy at which it is defined, each uniquely identified contracted, backup, and spot carriers, and the contract linehaul (point-to-point) price for the contracted carrier-lane combination. Each shipper-procurement event-lane-carrier-price tuple is associated with a unique identifier, QuoteID.

The second dataset is the Tenders file. It consists of the complete tendering sequence and carrier acceptance decisions for each load that materializes over the date range for the shippers. Each load is assigned a unique LoadID number. However each load may appear in the dataset once (e.g., the shipper tenders the load to the primary carrier, which accepts it) or multiple times (e.g., the shipper tenders the load to the primary carrier, which rejects it, the shipper then tenders the load to the first backup carrier, and so on until the load is accepted). The Tenders file also includes the time and date of each load tender, carrier identification information, price at which the load was offered to each carrier, and the QuoteID associated with the shipper-bid event-lane-carrier for that load. The QuoteID links the Tenders and Cost Quote files together.

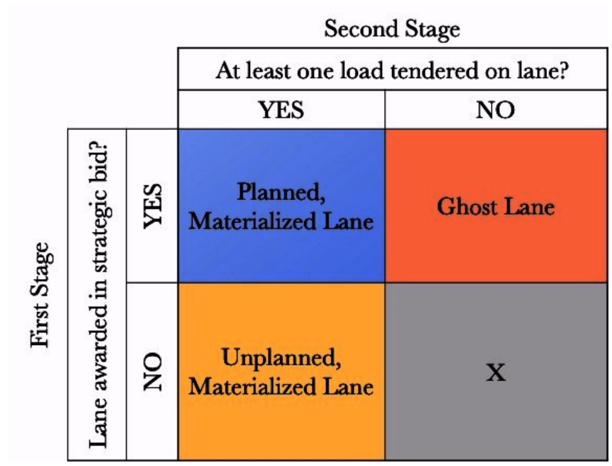
The final file, called Loads, is comprised of each shipment. Specifically, each unique load (LoadID) appears strictly once. It includes the geographic origin and destination information from warehouse address level to State, the carrier that ultimately accepted the load, the time and date stamps for the truck's arrival at and departure from the pickup and drop-off facilities, the linehaul price paid to the accepting carrier, and the distance the load was moved. The LoadID links the Loads file to the Tenders file.

5.2. Ghost lane identification and frequency

We identify each shipper's procurement event dates over the timeframe with a method described in Bandaru and Dolci (2020) as well as how often contracted lanes end up as ghost lanes - that is, the extent to which ghosting happens. We use the Tenders file to flag each lane as either Ghost or Materialized in the Cost Quotes file based on the QuoteID. That is, if QuoteID for the shipper-procurement event-origin-destination-carrier-price tuple (S1-Y1-O1-D1-C1-P1) exists in the Cost Quotes file, the associated shipper, S1, contracted the volume on that specific lane (O1-D1) to carrier C1 at contract price P1 during the strategic procurement event for year Y1. If QuoteID (S1-Y1-O1-D1-C1-P1) appears in the Tenders file *and the tender date is within the effective date of the contract following the bid event*, the lane is a materialized lane: shipper S1 has offered at least one load on that lane to the contracted carrier during that year. Conversely, if QuoteID (S1-Y1-O1-D1-C1-P1) does not appear in the Tenders file, the lane is a ghost lane: the shipper has awarded the lane to the contracted carrier but never offered any of the planned, expected business.

The top row of the 2x2 matrix in Figure 5.2 demonstrates these outcome possibilities. An additional type of lane that occurs is the unplanned lane. This is when the shipper does not award a lane to any carrier during the strategic procurement stage but requires transportation services on that origin-destination pair. These are outside the scope of the present study.

Next we explore the frequency at which shippers ghost their contracted carriers. For each shipper's procurement event, we determine the percent of total lanes that turn out to be ghost lanes as compared to materialized lanes. The ghost lanes category is further broken up into full and partial ghost lanes. A shipper may contract a single lane to more than one carrier and split the volume that materializes across the carriers to help even out high-volume or surge volume lanes.



Ghost vs. Materialized Lane Matrix

However, if the shipper contracted more than one carrier to a lane but subsequently tenders all materialized volume to only one carrier, at least one other carrier will perceive the shipper as having ghosted it on the lane. In this case, the lane is considered a partial ghost lane. That is, a lane on which *at least one contracted carrier* is ghosted. A full ghost lane, on the other hand, is a lane on which none of the contracted carriers - regardless of how many there are - receive any volume over the course of the contract.

We make this distinction between full and partial ghost lanes for two reasons. First, it highlights the notion that ghosting occurs predominantly from the carrier's perspective. The carrier only knows what business it sees. It does not know what volume another carrier is offered on any lane. Ghosting poses a risk of straining the relationship, as we study in RQ2. Second, ghosting can come about for a variety of reasons. Full ghosting is most likely the result of poor forecasting on the shipper's part. The shipper may have expected to need the contracted capacity but for some reason, the volume did not materialize. On the other hand, partial ghosting is a specific decision the shipper makes. In this case, volume on the lane has materialized but the shipper chooses to offer none of that business to at least one contracted carrier.

Figure 1 demonstrates the average percent of lanes that end up as ghost or materialized across the 22 shippers in our datasets for each year of the five full years of procurement and tendering data.

One particular point stands out from Figure 1: ghost lanes represent 70 up to potentially 80% of lanes procured by shippers each year. For practitioners including our partner company, this ghost lane rate is surprisingly high. As discussed, procuring eventual ghost lanes is costly and inefficient for shippers and receiving contracts for ghost lanes is disruptive for carriers. This raises two key

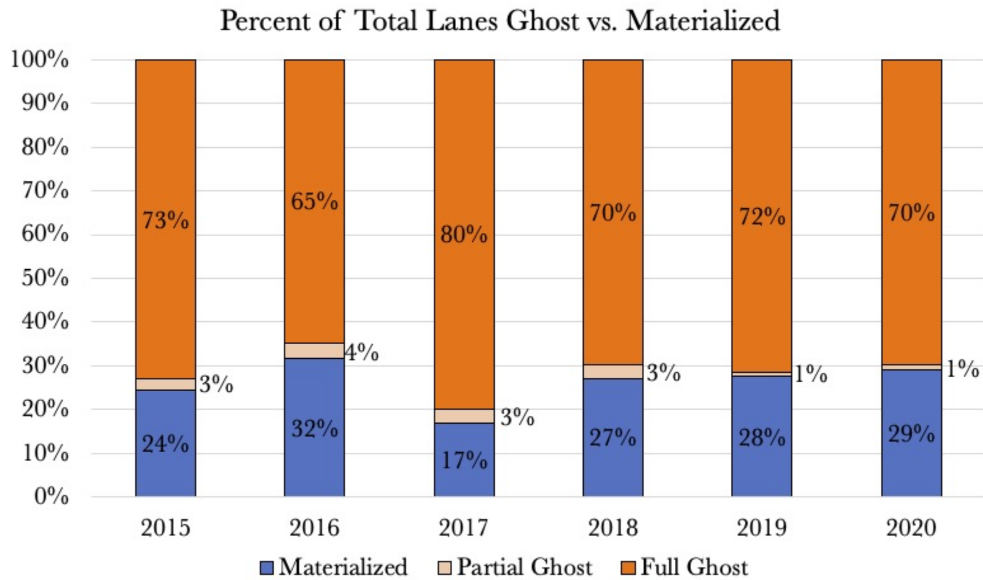


Figure 1 **Ghost vs. Materialized Lane outcomes as percentage of all lanes in the annual RFP**

concerns: how can shippers and carriers identify ghost lanes before they happen (RQ1)? And how much of an impact does this ghosting practice have on carrier performance and costs to the shipper (RQ2)?

6. Methodology

To address our two research questions, we develop a set of empirical models to describe the relationship between the variables of interest and the factors we hypothesize predict them. Our first model addresses RQ1. The unit of analysis is the lane level. It describes lane characteristics known at the procurement event that shippers and carriers can use to determine the likelihood it will end up a ghost lane. The variables are described below and summarized in Table 1. Our second set of models address RQ2. Here, the unit of analysis is the shipper-carrier-procurement year. We measure the percent of lanes that end up as ghost lanes between a shipper and contracted carrier in one year and determine how it factors into the contracted carrier's load acceptance rate and contract price competitiveness the following year. The important variables are summarized in Table 2 In addition, we control for a set of shipper, carrier, and lane factors that impact carrier performance and contract prices. We detail each model in the sections below.

6.1. Characteristics of ghost lanes

Our dependent variable for this analysis is whether a lane is a ghost lane. It equals 1 if the lane is contracted to a carrier in year t but no loads are tendered to that carrier on the lane before the shipper's next procurement event. It equals 0 otherwise (i.e., it is a materialized lane). Shippers -

and carriers to a much lesser degree depending on what the shipper is willing to share - have some information about each lane at the time of procurement. We describe these known characteristics below.

New Lane: We capture whether the lane in question is new in the shipper's network with an indicator variable, $New_{i,j}$, where origin and destination of the lane are denoted by i and j, respectively. When shippers open new facilities, anticipate new customer locations, or shift production locations, they expect to need transportation providers to serve these new origin-destination combinations. Even if volume has not begun on the lane by the procurement event, shippers often include these lanes in the RFP to secure a contract price for loads that may eventually need to be moved. Since these new lanes are more uncertain than established lanes in a shipper's network, we expect they are more likely to end up as ghost lanes.

Geographic Granularity: Shippers define contracted lanes by their origin and destination, each at a certain level of geographic granularity. For example, a lane's origin or destination could be defined at a warehouse address, a 5-digit zip code, a city, a 3-digit zip code, or a state. Shippers combine demand for lower-volume, inconsistent lanes to have more consistent demand patterns by defining them at a less granular level (Caplice and Sheffi 2003). Perhaps the shipper has multiple customers' facilities in this destination region. Rather than contracting multiple carriers each at a different price for each of these nearby customers, the shipper may aggregate their demand and contract based on this destination region.

A lane's geographic aggregation informs its potential volumes. We expect volume on lanes defined at a less granular level is less certain and thus more likely to contribute to it becoming a ghost lane.

The origin and destination aggregation level variables in our model are Geo_i and Geo_j, respectively. These ordinal variables are coded to take values of 1-5. Higher values represent decreasing granularity levels: (1) facility address, (2) 5-digit zip code, (3) city, state, (4) 3-digit zip code, (5) state.

Carrier Service Type: We include a variable describing the contracted carrier's service type (asset vs. non-asset broker) $Broker_c$. In this way we control for a potentially confounding variable. As discussed in Section 4, shippers utilize asset carriers and brokers for different purposes based on their service specializations and efficiencies Acocella et al. (2020), Scott (2018). The binary $Broker_c$ variable takes value of 1 is the carrier is a non-asset broker and 0 if it is an asset-based carrier that owns the fleet of trucks used to move loads.

Market Condition: Finally, shippers' and carriers' behaviors are impacted by freight market trends (see, e.g. Acocella et al. (2020), Scott et al. (2016), C.H. Robinson (2015)). In a soft freight market, demand for transportation is low compared to capacity availability. On the other hand, in a tight market, demand outstrips capacity. As such, we expect the potential for ghost lanes to be higher during soft market periods when shippers' demand is less than anticipated. It has been demonstrated that the market was soft during 2015, 2016, and 2019 and tight during 2017, 2018, and 2020 (Acocella et al. 2020, Coyote Logistics 2021). We include an indicator variable for the market condition in which the lane is procured: $Tight_t$. It takes a value of 1 if the procurement happened for the latter set of year listed above and 0 otherwise. We expect the likelihood a lane becomes a ghost lane to be higher during soft market procurement years and lower during tight procurement years. The model variables are summarized in Table 1 below.

Variable	Definition	Mean	St.Dev.
$Ghost$ $Lane_{i,j,t}$	1 if lane (i,j) exists in bid event for year t but no loads offered on it to contracted carrier in t; 0 otherwise (i.e., materialized).	0.93	0.25
$New_{i,j}$	1 if lane (i,j) has not previously been procured by the shipper	0.84	0.37
$Geo_{i/j}$	Geographic granularity level of the origin/destination, i/j; ordinal variable	3.14(i) 3.19(j)	0.71(i) 0.74(j)
$Broker_c$	1 if the carrier is a broker/non-asset provider, 0 if asset-based	0.88	0.32
$Tight_t$	1 if year t is during a tight market condition	0.57	0.50

N = 51,711

Table 1 Summary of Variables, Ghost lane prediction model

We also control for the shipper's industry vertical to account for potential fixed effects. The binary outcome of a lane (i,j) becoming ghost (1) or materialized (0) is described in Equation 1.

$$\Pr(Ghost_{i,j} = 1 | x_{i,j,c,t}) = \frac{\exp(\eta_{i,j,c,t})}{1 + \exp(\eta_{i,j,c,t})} \tag{1}$$

Where

$$\eta_{i,j,c,t} = \beta_0 + \beta_{New} New_{i,j} + \beta_{Geo_i} Geo_i + \beta_{Geo_j} Geo_j + \beta_{Broker} Broker_c + \beta_{Tight} Tight_t + \epsilon_{i,j,c,t}$$

The logistic regression model results give the probability a lane becomes a ghost lane given the characteristics described above. The coefficients in $\eta_{i,j,c,t}$ express if and how the characteristics factor into the ghost lane likelihood. Next, we discuss the empirical models that address RQ2.

6.2. Ghosting impacts on future carrier performance and contract prices

Our second analysis consists of two dependent variables and models. One is the percent difference between the specific contracted carrier's freight acceptance rate and the average contract carrier freight acceptance rate at that time, or Acceptance Rate Differential, $ARD_{c,t+1}$. The non-binding TL contract allows contracted carriers to reject loads tendered to them. Hypothesis H2a suggests that carriers do not prioritize the freight from shippers that have demonstrated a high rate of ghost lanes in the past. Contracted carrier freight acceptance rate is measured as the number of loads accepted by the contracted carrier on a lane relative to the total number of loads tendered to the contracted carrier on that lane over a year (Acocella et al. 2020). This is then averaged across all the carriers' contracted lanes with a given shipper in that year t. Our $ARD_{c,t+1}$ variable is the percent difference in the acceptance rate of the contract carrier of interest and the average acceptance rate of carriers in year $t+1$.

Our other dependent variable is contract market price differential on a lane contract price in the year following ghosting, $MKD_{c,t+1}$. That is, the contract price's percent above or below (premium or discount, respectively) the going lane-specific market price. This tells us how competitive the carrier's prices are. A higher market rate differential suggests the carrier requires a higher price to serve this shipper. We expect that more ghosting in one year corresponds to a carrier requiring higher contract prices the following year for that shipper.

To calculate market rate differential, the lane-specific market price must be established. There are many buyers and many sellers of truckload transportation and there is no central decision maker on prices. Moreover, prices are not public. As such, we have an implicit market (Rosen 1974); the market is thick on both sides and no one buyer or seller is a price setter (Hubbard 2001).

We follow methods similar to those by Acocella et al. (2020), Caplice (2007), Ballou (1991); and Scott (2015). The linehaul (point-to-point) contract price of all 3.8 million loads from 2015-2020 is regressed on an origin and destination 3-digit zip code region indicator, year indicator, and the distance of the load. This is a common approach to determine prices for implicit markets (Denning et al. 1994). The result is a "market" contract price for every origin-destination-year (i, j, t) combination: $Market\, Price_{i,j,t}$. If $P_{c,i,j}$ is the contract price on lane (i, j) for carrier c and $N_{i,j}$ is the number of (i, j) combinations, the contract market price differential in year t, then is defined as:

$$MKD_{c,t} = \frac{1}{N_{i,j}} \sum_{\forall(i,j)} \frac{P_{c,i,j} - Market\, Price_{i,j,t}}{Market\, Price_{i,j,t}} \tag{2}$$

The common set of five independent variables for Hypotheses **H2a** and **H2b** describe the shipper-carrier relationship, the carrier characteristics, and the market conditions. The set of relationship measures have been established as important factors to the operational and strategic relationships between transportation buyers and suppliers (Griffis et al. 2007).

Ghost Percent: The main variable to test our hypotheses is the percent of lanes contracted to a carrier by a shipper in year t that end up as ghost lanes in that year: $Ghost\,Percent_{c,t}$. This tells us if, holding all else equal, there is a correlation between a shipper's ghosting tendencies in one year and that carrier's freight acceptance rate (**H2a**) or contract pricing (**H2b**) the following year.

Network Percent: We control for the relative importance of the carrier to the shipper with the variable $Network\,Percent_{c,t}$, which is the percentage of a shipper's lanes that are contracted to that carrier in year t. Carriers that represent a higher Network Percent may be more likely to be ghosted due to the sheer number of lanes it covers. On the other hand, contracting on a higher percent of a shipper's lanes indicates an important business relationship (Rinehart et al. 2004) and may contribute to higher freight acceptance rates or lower, more competitive contract prices. Therefore, we control for these contributions by including the Network Percent variable in our models.

Importantly, most carriers in the dataset (¿75%) represent no more than 20% of a shipper's network (the median value is 3%). To manage the skewed continuous $Network\,Percent_{c,t}$ variable, instead of including it directly in the model, we use a binary variable the indicates if the carrier represents a *low* percentage of the shipper's network. This variable is $Low\,Network\,Percent_{c,t}$, which takes value of 1 if the carrier's $Network\,Percent$ is less than or equal to 3% and 0 otherwise.

Carrier Service Type: With binary variable $Broker_c$, we control for the carrier service type. Acocella et al. (2020) and Scott (2018) demonstrate that carrier service type are significant contributing factors to carrier acceptance rates and prices.

Ghost Percent, Network Percent interaction: We include a term that captures the interaction of a shipper's ghosting rate to a carrier in year t and the carrier's importance to that shipper, as measured by the (continuous variable) Network Percent in the following year, $t+1$. Recall, we expect the coefficient on Network Percent in any given year to be positive in the market differential model and negative in the acceptance rate model. This is because a carrier that is contracted on a higher percentage of the shipper's network is more likely to cover more unattractive, low-volume, tail lanes, including those with less certain demand that are more likely to be ghost lanes. We include this interaction variable to control for this potential relationship between Ghost Percent and Network Percent.

Second, taking the example of the market rate differential model, assuming positive coefficients on each of the terms independently, a positive interaction relationship (i.e., interaction coefficient) indicates that if a carrier is ghosted at a high rate in year t, contracting it on more lanes the following year would only further inflate its contract price premium.

On the other hand, a negative interaction term coefficient indicates that the shipper's high rate of ghosting a carrier in year t, increasing the Network Percent by contracting with it on more lanes in the following year helps dampen the hypothesized adverse effects of ghosting. We include this interaction term to demonstrate one potential action a shipper can take after ghosting a carrier to mitigate the potential effects.

Market Condition: Similar to our model developed for RQ1, we include an indicator variable, $Tight_t$, which denotes if the procurement event occurred during a soft (0) or tight (1) market condition. The market condition's impact on carrier acceptance rates and prices is demonstrated in Acocella et al. (2020), Scott et al. (2016), Pickett (2018). Thus we control for it in order to isolate the impact of ghosting on our variables of interest.

In our change in acceptance rate model, we also control for the average market rate differential in year $t+1$, as it has been shown to be a strong indicator for a carrier's likelihood of accepting freight (Acocella et al. 2020).

The resulting two models are defined as:

$$\begin{aligned} ARD_{c,t+1} = \beta_0^{ARD} + \beta_{Ghost}^{ARD} Ghost\,Percent_{c,t} + \beta_{Low\,Net}^{ARD} Low\,Network\,Percent_{c,t} + \beta_{Broker}^{ARD} Broker_c \\ + \beta_{Tight}^{ARD} Tight_t + \beta_{Ghost \times Net}^{ARD} Ghost\,Percent_{c,t} \times Network\,Percent_{c,t+1} + \beta_{MKD_{t+1}}^{ARD} MKD_{t+1} + \epsilon^{ARD} \end{aligned} \tag{3}$$

$$\begin{aligned} MKD_{c,t+1} = \beta_0^{MKD} + \beta_{Ghost}^{MKD} Ghost\,Percent_{c,t} + \beta_{Low\,Net}^{MKD} Low\,Network\,Percent_{c,t} + \beta_{Tight}^{MKD} Tight_t \\ + \beta_{Broker}^{MKD} Broker_c + \beta_{Ghost \times Net}^{MKD} Ghost\,Percent_{c,t} \times Network\,Percent_{c,t+1} + \epsilon^{MKD} \end{aligned} \tag{4}$$

The data on which the model are aggregated to the shipper-carrier-procurement event year level. As the same shipper-carrier combination is represented many times within the dataset (e.g., over time and across lanes), we use a Generalized Estimating Equations (GEE) method to calculate the coefficients (see Hardin and Hilbe (2012), Greene (2003)). In this way we account for the covariance matrix between the outcomes in the sample associated with the same shipper-carrier combination and obtain the average response of a carrier to a shipper across the population (Liang and Zeger 1986, Ballinger 2004).

We calculate the contracted carrier acceptance rate differential and market rate differential across all lanes between a shipper and carrier in a given year and across only lanes with at least 52 loads in the year - that is, about one load per week. These moderate- to high-volume lanes are most important to shippers and carriers alike for budgeting and capacity planning. Both parties prioritize these lanes rather than low-volume, or "tail", lanes. For example, in our dataset, 14.5% of the total 9.6 thousand unique lanes have more than 52 loads in the year. While a small percentage of total lanes, these mid- and high-volume lanes represent 70% of total volume (number of materialized loads). It is a common characteristic in TL transportation for a small fraction of lanes to represent the overwhelming majority of volume. As such, shippers are more concerned with high acceptance and competitive prices on these important lanes.

Variable	Definition	Mean	St.Dev.
$MKD_{c,t+1}$	Carrier c contract price percent above or below lane benchmark price in year $t+1$	0.00	0.28
$ARD_{c,t+1}$	Percent change in fraction of loads tendered to contracted carrier c relative to number it accepts	0.03	0.51
$Broker_c$	1 if the carrier is a non-asset broker, 0 if asset-based	0.85	0.35
$Tight_t$	1 if year t is during a tight market condition	0.61	0.49
$Ghost\ Percent_{c,t}$	Percent of lanes contracted to carrier c in year t that end up as ghost lanes	0.34	0.25
$Network\ Percent_{c,t}$	Percent of shipper's network of lanes that are contracted to carrier c in year t	0.13	0.21
$Low\ Network\ Percent_{c,t}$	1 if $Network\ Percent_{c,t}$ is less than the median of 3%, 0 otherwise	0.46	0.50
$Ghost_{c,t} \times Network\ Percent_{c,t+1}$	Interaction term between ghost rate and network percent	0.05	0.10

N = 537

Table 2 **Summary of Variables, MKD and ARD models**

7. Results

In this section, we discuss the results of our three empirical models. The first helps shippers and carriers alike to preemptively identify potential ghost lanes before transportation capacity is contracted on them. This helps shippers remove unnecessary lanes from the traditionally long, tedious, and costly procurement process. The second two models help shippers understand whether ghosting contracted carriers in one year contributes to that carriers' freight acceptance decisions the following year or its bid (and resulting contract) prices during the next annual procurement event.

7.1. Identifying potential ghost lanes

Table 3 summarizes the logistic regression results that address RQ1 and the characteristics of ghost lanes. Hypothesis **H1a** is supported: a lane's likelihood of becoming a ghost lane is higher if it is new - that is, it has not been procured by the shipper the year before. This is the aspect of a coverage strategy where the shipper tries to ensure there is contracted capacity for all potential volume it expects in its network. In fact, 85% of all ghost lanes in a given year are new and not contracted in the previous year.

Figure 2 shows the distribution of ghost lanes' volume tendered in the previous year. Note this substantially large number of ghost lanes that are new that year. This is compared to the remaining ghost lanes that are not new and have been procured the previous year. Most of these ghost lanes (about 6% of all ghost lanes or 40% of *not* new ghost lanes) had no volume materialize on them when they were contracted in the previous year. Another 4% of all ghost lanes (or 30% of previously contracted ghost lanes) had from 1 up to 10 loads tendered on them to the contracted carrier the previous year. This suggests that existing lanes that had no or very low volume in the previous year are also likely to be ghost lanes. These are prime candidates to be removed from the full procurement event.

Variable	Coefficient	St. Error
$New_{i,j}$	1.21***	0.04
Geo_i	0.20***	0.03
Geo_j	0.47***	0.03
$Broker_c$	-0.37***	0.06
$Tight_t$	-0.37***	0.04
const	0.21*	0.13

Notes: Pseudo $R^2 = 0.12$; N=51,711

Significance levels: *0.1; **0.05; ***0.01

Table 3 Model Results: ghost lane prediction

The results of our model also reveal that the lower the geographic granularity level at which the origin and destination of the lane are defined, the more likely it is to become a ghost lane, which supports Hypothesis **H1b**. Again, this suggests a coverage strategy based on lane volume aggregation. Our results suggest this coverage strategy to greatly contribute to ghosting.

Further, we find that asset-based carriers are less likely to receive ghost lanes than non-asset brokers, supporting Hypothesis **H1c**. This may be explained by shippers' tendency to contract brokers on less certain lanes in general.

Finally, the results support Hypothesis **H1d**, suggesting that ghost lanes are less likely to occur during tight market conditions and more likely in soft markets. By definition, in a soft market, less volume materializes than available capacity. This speaks to the difficulties in forecasting long-term demand on a shipper's transportation network wherein lanes that were meant to bear volume did not fulfill the expectations and become ghost lanes. However, with both their own interactions with suppliers and customers and the ease of access to freight analytics and market trends, shippers and carriers are aware of current market conditions. Incorporating that knowledge into the strategic procurement decisions can help shippers reduce ghost lane occurrence.

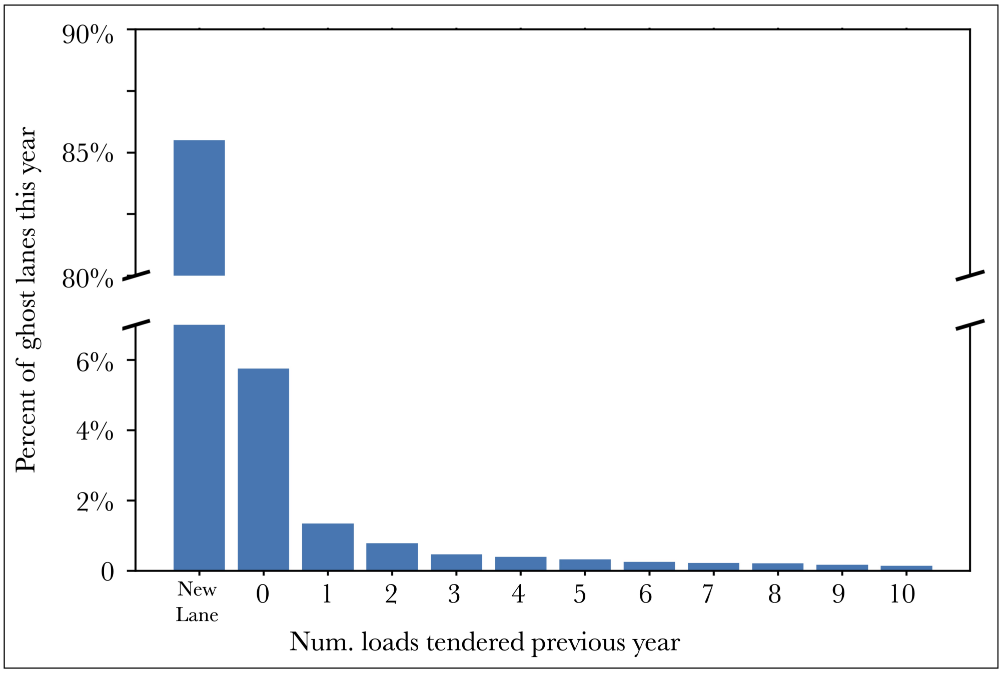


Figure 2 **Ghost lanes' previous year volume**

7.2. How ghost lanes contribute to carrier behavior

Results from our models of ghost lane rate contributions to carriers' future change in freight acceptance rate and contract market rate differential are summarized in Table 4.

First, we discuss the primary carrier acceptance rate model. In general, a higher rate of ghost lanes to a contracted carrier in one year does not show significant contribution to lower carrier acceptance rates the following year; we reject **H2a**. However, as expected, the competitiveness of the contract price in a given year (MKD_{t+1}) is a strong indicator for carrier acceptance (Acocella et al. 2020, Scott et al. 2016).

Variable	ARD_{t+1}		MKD_{t+1}	
$Ghost\,Percent_{c,t}$	-0.02	(0.09)	0.10**	(0.05)
$Low\,Network_{c,t}$	-0.04	(0.05)	-0.10***	(0.03)
$Broker_c$	0.00	(0.06)	-0.06**	(0.03)
$Tight_t$	-0.33***	(0.04)	0.09***	(0.02)
$Ghost \times Network$	0.29	(0.26)	-0.25	(0.13)
MKD_{t+1}	0.16**	(0.08)	-	
const	0.27***	(0.07)	0.02	(0.04)
Adj. R^2	0.10		0.06	

Notes: Robust standard errors reported in parentheses;

N=537; Significance levels: *0.1; **0.05; ***0.01

Table 4 Ghosting impact on acceptance rate and price

On the other hand, the positive and statistically significant coefficient on $Ghost\,Percent_{c,t}$ in the MKD_{t+1} model provides evidence that a higher rate of ghost lanes to a contracted carrier indicates higher (less competitive) contract prices from that carrier the following year, supporting **H2b**.

As expected, controlling for the factor measuring the size of the shipper-carrier relationship, namely the Low Network Percent variable, is important in isolating the effect of ghosting, particularly in the market rate differential model. That is, the coefficient for $Low\,Network\,Percent_{c,t}$ is significant, and negative. This suggests that carriers representing a lower percentage of a shipper's network have lower, more competitive contract prices than carriers contracted on more of the shipper's network. This may be explained because carriers contracted on a higher percent of a shippers' lanes may be covering more unattractive lanes (i.e., high variability, low volume, etc.), which could lead to higher prices.

The positive and significant tight market indicator variable coefficient in both models corroborates previous studies' findings that shippers typically see lower primary carrier acceptance rates and pay higher contract prices during tight markets.

Finally, the interaction term between Ghost Percent in t and Network Percent in $t+1$ is not significant in either model. Therefore, we do not show evidence that there is a relationship between shipper's ghosting patterns than the prevalence of a carrier within its network.

8. Effectiveness of a coverage procurement strategy

Our main results suggest that there are unanticipated costs to shippers' coverage strategy. However, shippers implement such an approach expecting to reduce exposure to the spot market and to establish competitive contract prices during the first stage procurement process. In this section, we empirically examine the effectiveness of the coverage strategy. In particular, we explore the contracted carrier rejection rates and established contract price compared to the going spot market price for lanes that are most likely to become ghost lanes (i.e., new lanes) but on which volume does in fact materialize.

New lanes are most susceptible to becoming ghost lanes; only 5% of new lanes actually materialize. Contracts on those new lanes that materialize underperform on both measures. On average, freight rejection rates are high at 27% each year. This means that for more than one in four loads on new lanes, the shipper cannot count on the contracted carrier to accept a tender. Moreover, when the contracted carrier does accept these loads, the contract prices that are in place are higher than the spot market price for loads on that lane at that time. Specifically, contracts prices on new lanes are 13-40% higher than going spot prices. In other words, the shipper is overpaying for volume on these lanes.

If the coverage strategy both costs shippers more for contracts the following year as a result of ghost lanes, which we demonstrate in the main analysis, and the approach is not effective even when volume does materialize on lanes that are characteristically ghost lanes, demonstrated here, then why are shippers utilizing a coverage strategy at all?

As discussed earlier, shippers seek to reduce expected administrative costs later on for materialized lanes. Then the shipper must be sure these cumulative administrative costs upfront are warranted. Our empirical analysis demonstrates the true upfront costs to the shipper for coverage are quite high and shippers must consider these costs carefully. Ours is the first study that explicitly considers these costs.

9. Contributions and Managerial Implications

We offer four contributions with this work. First, our study is the first to define and measure the frequency at which ghost lanes occur - a highly inefficient and costly outcome of outdated procurement practices. Second, we identify the characteristics of potential ghost lanes. The importance of identifying them early - before procurement - is underscored by our third contributions; we measure the cost of ghosting and how it factors into contracted carriers' future behaviors. Our fourth and final contributions is to the existing literature on procurement strategy. Here, we study an example of buyers' choices to reduce risk from both supply and demand uncertainty by implementing a coverage strategy by securing contracted services across all expected demand. The results of our study suggest this coverage strategy has its costs and that shippers should update their approach to procuring TL transportation. In this way they can reduce both the setup costs and future contract prices associated with this strategy.

9.1. Frequency of ghosting

Much of the relevant literature on TL transportation contracts and operations implicitly assumes the shipper's business offering adheres to the expectations of the contract - that is, the volume offered is roughly the amount forecasted and communicated in the contract. Instead, studies tend to focus on bid execution (e.g. Song and Regan (2005), Caplice and Sheffi (2003), Basu et al. (2015)), cost minimizing carrier-load matching decisions (e.g., Tjokroamidjojo et al. (2006), Regan et al. (1998)), or improving carrier service at the network level (e.g., Scott et al. (2016), Acocella et al. (2020), Zsidisin et al. (2007), Adelman and Mersereau (2013)). However, the extent to which shippers deviate from the planned demand has yet to be explored. Moreover, we observe that the risks associated with these outcomes leads shippers to reduce exposure risks with a coverage approach.

Our empirical data exploration shows that the majority of lanes (67-80%) for which shippers have contracted capacity are not used at all - that is, the shipper offers no business at on these lanes, which become ghost lanes. The question then becomes how shippers can curtail this practice to limit the the time and resources spent to send out RFPs to carriers, collect bid prices, negotiate with carriers, solve large-scale carrier assignment optimization problems for thousands of lanes for so many that may be unnecessary.

9.2. Early detection of potential ghost lanes

To our knowledge, segmentation strategies to help shippers identify which pieces of their TL service needs should be procured in different ways has not been explored in the literature. One related stream of literature that explicitly considers differences between TL lanes deals with lane bundling - that is, how to optimally create and price a collections of different lanes (see for example, Caplice and Sheffi (2003, 2005), Chen et al. (2009), Song and Regan (2005), Figliozzi et al. (2007)).

However, while this stream of literature recognizes that each TL lane can be more or less attractive (i.e., profitable) for carriers, it does not consider the option to eliminate the lane from the bid altogether. In practice in the TL procurement process, shippers identify lanes on which they prefer to maintain or extend existing contracts with providers, and which ones they may want to add or remove from their contracted network. We take an alternative approach to that discussed in the literature previously in order to suggest to shippers which lanes to exclude from the costly bid process.

We can preemptively identify lanes that are likely to become ghost lanes as those that are new to the shipper's network. In fact, only about 5% of new lanes end up materializing volume that year. Upon further exploration, we find that these new lanes on which volume does materialize represent about 11% of shippers' total materialized volume for the year. While we suggest shippers consider removing new lanes from the annual procurement event to reduce the unnecessary associated costs, doing so would move this volume to the "Unplanned" category (bottom left cell in Figure 5.2). This has its drawbacks, including heightened performance uncertainty and financial risk for the shipper.

Upon initial exploration of potential differences between new lanes that are ghost lanes compared to new lanes that materialize, we do not find major differences. We consider potential differences across shippers, years, and contracted carrier service level as well as lanes' definition granularity and geographic locations. Thus, we suggest further analysis of these and other potential differences to help shippers identify which new lanes should and should not be included in the annual procurement event. More specifically, on which new lanes is volume more likely to materialize.

Further, lanes that have a higher geographic aggregation region for origin and/or destination definition are likely to end up as ghost lanes. Shippers should move away from a coverage strategy; rather than including every potential lane that may need capacity in the traditional procurement process to ensure it has a contract price on file, shippers should rely on other options if volume does materialize.

There have been a few shifts in shipper's strategies for lanes that are removed from the full procurement event. One is with more frequent, smaller procurement events, called "mini bids" in between the annual, full network procurement event. During these mini bids, shippers bid out a specific segment of their networks, perhaps only to a few select core carriers. These specialized mini bids are opportunities for shippers to adjust under-performing lanes previously bid out or to establish a contracted carrier and price on newly materialized lanes.

We also find that ghosting happens more frequently during soft markets than tight. Between freight analytics providers, media outlets, and their own experiences with suppliers and customers, transportation practitioners typically have a good sense of the current market conditions - albeit the future outlook of market dynamics is difficult to plan for. Our study suggests that shippers can comfortably remove lanes with higher potential of ghosting from the full procurement event if it occurs during a soft market and rely more heavily on the mini bid or brokerage alternatives.

9.3. Ghost lanes' cost implications

The second research question is whether carriers are disrupted enough by ghosting for it to contribute to their performance and price competitiveness in the future, particularly on important lanes. Here, we contribute to the literature on TL contract execution and performance (e.g., Scott (2015), Acocella et al. (2020), Zsidisin et al. (2007)).

While we do not find significant evidence that higher rates of ghosting to a contracted carrier in one year contribute to lower freight acceptance rates from a carrier the next year, it does contribute to higher contract prices from the carrier that following year. Thus, ghosting implies not only higher, avoidable internal costs to the shipper at the time of procurement by including the unnecessary ghost lanes in the bid process, but higher contract prices in the future and potentially a strained relationship with carriers.

While the former costs related to the procurement process are difficult to measure, in this study we quantify the latter costs contributed by the contract price premium escalation. In particular, an increase of ghost rate of 10 percentage points increases the following year's contract price premium by 1.6 percentage points. However, we find that the effects of ghosting on contract price premium can be dampened if the shipper contracts a higher percentage of its network to that carrier the following year. Thus, our results underscore the importance for shipper to put a greater emphasis on carefully reviewing the outcome of previous year's strategic procurement and how well their demand matched the expectations before designing and executing their next full procurement event.

9.4. Coverage strategy resulting from poor contract performance

We can generalize our findings and make a final contribution to the literature on procurement strategy. In particular, the coverage strategy we identify in this context can impact future contract performance outcomes - in this case under relational, or non-binding contract agreements (Baker et al. 2002, Anderson and Dekker 2005). See also Tsay et al. (2018) for a review and framework of relevant literature that measure buyer-supplier relationships and identify their contract performance outcomes. Following this framework, we measure how supplier outcomes (carrier freight acceptance and contract price competitiveness) are impacted by previous buyer outcomes (shippers' ghosting tendencies) (e.g., Wathne and Heide (2000), Heide et al. (2007)). Measuring these outcomes, we demonstrate that this coverage strategy leads to inefficiencies for the carrier but also costs for the shipper itself. We employ an empirical analysis of behaviors that are typically unable to be captured with analytical models more commonly found in the literature. Empirical studies have also been used less frequently in previous studies due to data availability challenges.

10. Limitations and Future Research

Our study has some limitations, which imply potentially important future research. While we study empirical behaviors across a set of shippers and their contracted carriers - which is uncommon in empirical transportation research - our results should be taken in light of the data source. These shippers are subset of firms that are large enough to outsource their transportation management business unit to our partner company, TMC, yet small enough not to integrate the processes internally to capitalize on the potential efficiencies that in-house services provide. While we do not believe these shippers' operations or practices are unique to their size, it is not an impossibility. Moreover, as with any empirical research, despite our best attempts to control for confounding factors based on our own experience and that of our partner companies, there are of course alternative explanations for our results. However, despite the limitations we do not believe they impact the importance or generalizability of the results.

Our research is the first to define and explore the frequency and implications of ghost lanes. However, there is still much that should be explored. As noted earlier, a deeper exploration of new lanes' characteristics that indicate if volume will materialize on it or not - and thus result as a ghost lane - would benefit shippers looking to reduce their procurement event size and associated costs. Another interesting avenue would be to quantify the true cost of procuring lanes to the shipper and to the carrier using a game theoretic or transaction cost economics lens, for example. Another interesting, applied study could develop a decision tool for shippers: building off our probability model of the likelihood a lane will become a ghost lane, determine the specific lanes that should be included in the full procurement event and which should be kept for an alternative option such as during a future mini bid or with flexible capacity once volume does materialize.

Finally, the converse of ghost lanes are unplanned lanes - those that were not part of the main procurement process but on which volume does materialize on them. An interesting and important extension of this work would consider how shippers should manage this unplanned volume; e.g., if, when, and how to incorporate them into main or mini bids, which carriers to work with, and how to keep unexpected additional costs down.

Acknowledgments

We graciously acknowledge Sherry Liu and Alex Miller of the Supply Chain Management program at MIT's Center for Transportation & Logistics for their data management efforts, and the teams at C.H. Robinson and its TMC division for providing both the data and critical perspectives on many iterations of this research. We would also like to acknowledge Jan Fransoo of Tilburg University for his enlightening conversations that continue to greatly improve the framing of this paper.

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