Reducing uncertainty in freight transportation procurement

Received (in revised form): 11th June, 2021

Chris Caplice

CHRIS CAPLICE
Chief Scientist, DAT Freight and Analytics, USA

Chris Caplice is the chief scientist for DAT Freight and Analytics. In this role he pioneered the development of the Freight Market Intelligence Consortium (FMIC). He is also a senior research scientist at MIT and serves as the executive director of the MIT Center for Transportation and Logistics (CTL) as well as the co-director and founder of the MIT FreightLab — a research initiative that focuses on improving the way freight transportation is designed, procured and managed. He received a PhD from MIT in transportation and logistics systems, a MSCE from the University of Texas at Austin and a BSCE from the Virginia Military Institute. Chris was named the Silver Family Research Fellow in 2016.

DAT Freight and Analytics, Massachusetts Institute of Technology, 1 Amherst Bldg E40-255, Cambridge, MA 02142, USA
Tel: +1 617-258-7975; Mobile: +1 617-818-3634; E-mail: caplice@mit.edu; chris.caplice@dat.com

Abstract

Securing sufficient truckload transportation capacity is a challenge for most shippers. The dominant design currently used across North America is to run an annual reverse auction collecting rates from carriers on each of their freight lanes (origin-destination pairings) and then feeding these rates into the shipper's transportation management system (TMS), which then uses a routing guide to determine which carrier to tender a load to when a particular shipment materialises. Unfortunately, the routing guide frequently fails. This results in the shipper having to use backup carriers or the spot market, thereby incurring much higher rates. This paper explains why the current dominant design arose in the first place and why it is no longer sufficient. Four promising practices that can improve the transportation procurement process for shippers, carriers and brokers are presented and discussed: Data-driven analysis, transportation portfolio management, dynamic contracting and continuous procurement. These practices are meant to complement the current procurement methods in order to reduce the risk and level of uncertainty for all parties by making the procurement process more dynamic and responsive to the market.

Keywords

truckload transportation, procurement, mini-bids, transportation portfolio management, contracting

In 2020, the US full truckload transportation market experienced unprecedented turbulence due to the COVID-19 pandemic and the subsequent lockdowns and business interruptions. The market was highly bifurcated with some shippers (essential retailers, grocers, food manufacturers, etc.) experiencing two times or higher increases in truckload volumes, while others (general retailers, durable goods manufacturers, food services distributors, etc.) saw significant decreases in volume. This sudden and dramatic shift in the distribution of loads across networks led to higher empty miles by carriers and a mismatch of capacity to demand at the lane, region and national levels. The average cost of

truckload movements was erratic as well, dropping 10 per cent year over year in April and May 2020 and then increasing by more than 20 per cent year over year in the autumn.

The impact on the market was dramatic. US trucking company failures nearly tripled in 2020 from the previous year,[1] demand measured by the ratio of loads to trucks jumped 132.5 per cent year over year in August on trucking's spot market,[2] and shippers had to absorb record-setting spot and contract rates while struggling to keep 2021 budgets from unravelling.[3] Interestingly, as shown in Table 1, while the total volume changes were relatively small, the percentage of freight moving under spot instead of contract rates increased by double digits in the two most common modes of truckload transportation: dry van and temperature control.

It is important to recognise that even with this dramatic increase in percentage of spot volume, contract rates still dominate — even in highly chaotic and tight markets. DAT Freight and Analytics actively monitors over US$110bn in truckload transportation across North America. In 2020, we found that 84 per cent of all shipments within DAT's Freight Market Intelligence Consortium (FMIC) moved under contract rates.[4] The percentage moving under spot in 2020 was almost identical to that moving under spot in 2018 — the last extremely tight truckload market. Historically, in any single month the percentage of volume moving under spot rates ranges between 10 per cent (in loose markets like spring 2016 or 2019) to 24 per cent (in tight markets like the second half of 2020).

While the absolute volume of shipments moving under spot rates was still quite small, they caused the most pain and uncertainty to shippers. Not only does it increase the workload for transportation planners, but higher spot volumes also drive higher rates. We found that the rise in the percentage of loads moving under spot rates is highly correlated (90 per cent over the last five years) to the spot premium ratio — defined as the average spot rate divided by the average contract rate (see Figure 1).

A general rule of thumb in the industry is that the spot premium ratio increases at about 2.5 times the increase in spot volume percentage in the market (see Figure 2). This means that even a small increase in the use of the spot market translates into a much higher probability of budget failure for a shipper.

Also, it is fairly well recognised that as spot rates go, so go contract rates … eventually. Historically, it can be seen that peaks in contract rates lag spot rate peaks by about 9 months (see Figure 3).

All of these factors led to a perfect storm in 2020 for shippers — that is, buyers of transportation services. This paper addresses how shippers can procure sufficient truckload capacity in the most efficient and effective manner to avoid the turbulence and disruptions typically

TABLE 1: Comparison of year over year, 2020 to 2019, changes in volume for contract, spot and overall for dry van and temperature control markets

Mode	*Contract*	*Spot*	*Overall*
Dry van	+ 1%	+ 47%	+ 5%
Temperature control	- 6%	+ 22%	- 3.3%

Source: DAT FMIC (2021)

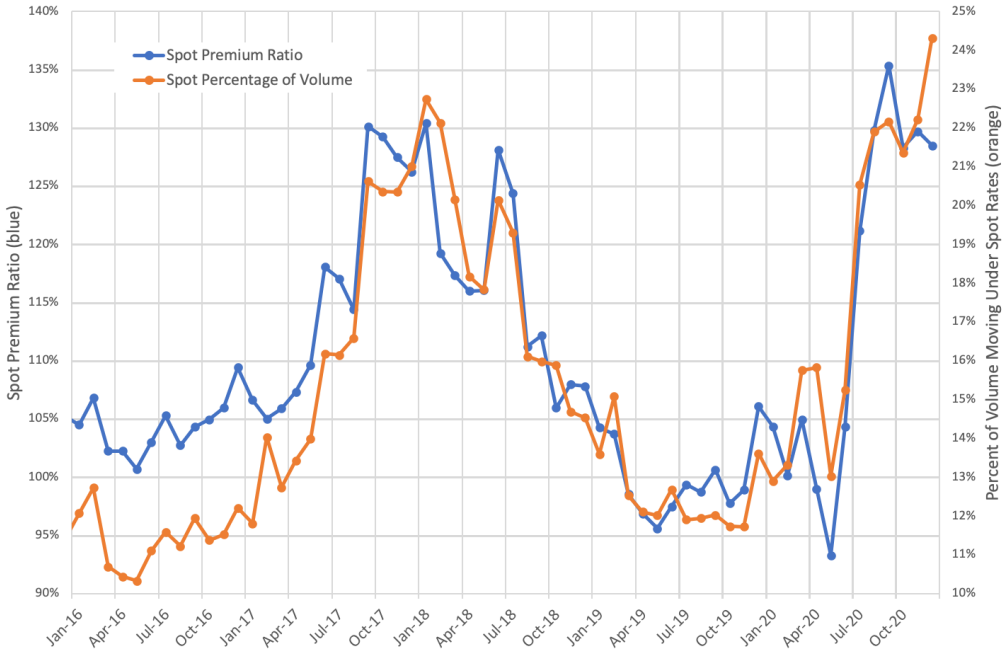

FIGURE 1: The monthly spot premium ratio and percentage of volume moving under spot rates for long haul dry van over the last five years
Source: DAT FMIC (2021)

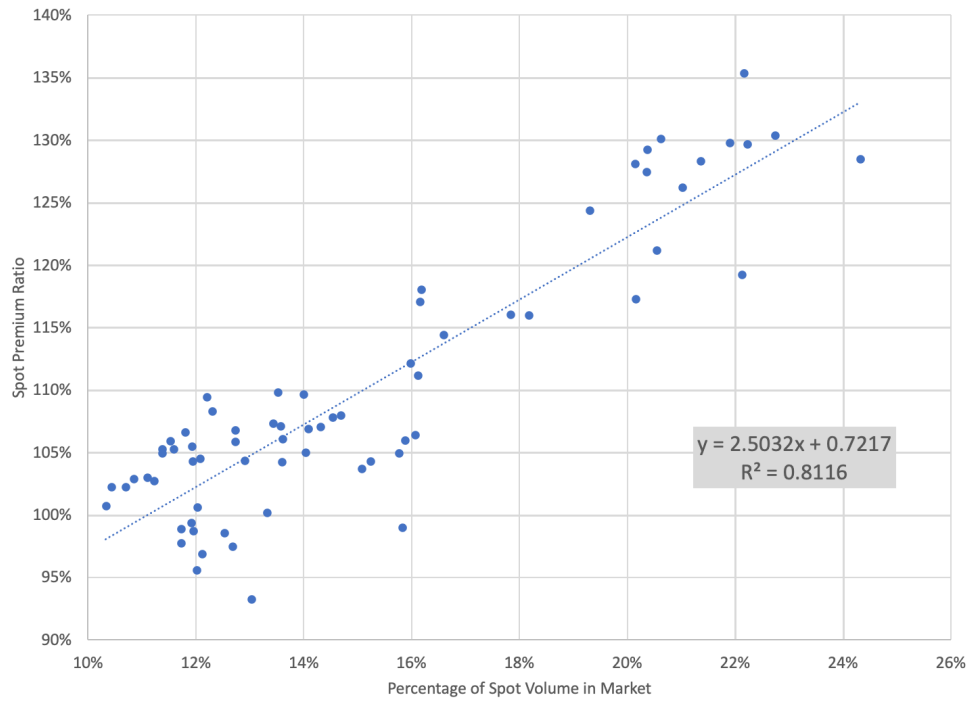

FIGURE 2: The monthly spot premium ratio and percentage of volume moving under spot rates for long haul dry van over the last five years. The simple linear trend shows that every percentage change in spot volume corresponds to a 2.5 percentage increase in the spot rates paid

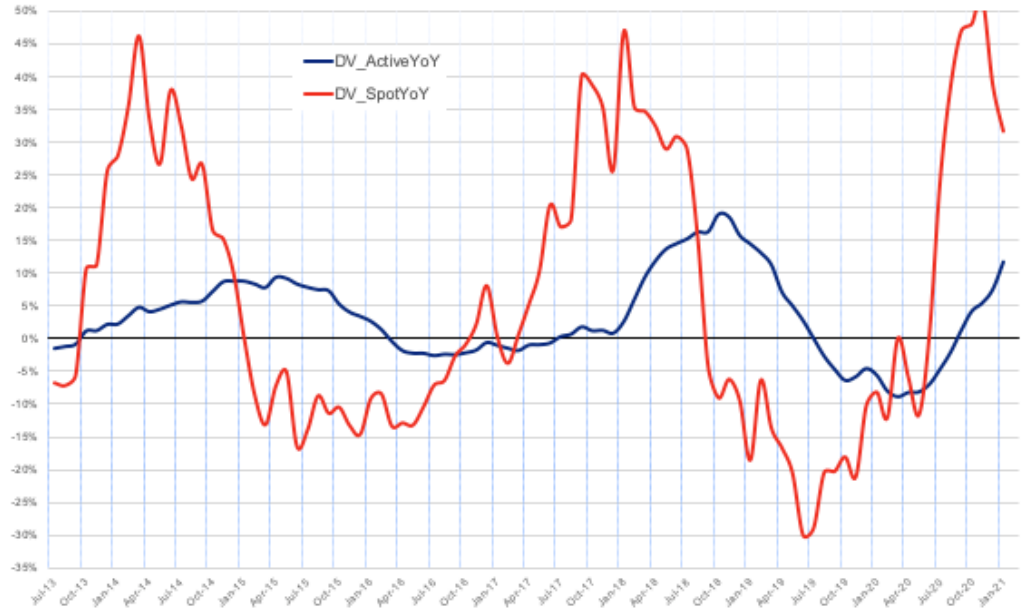

FIGURE 3: The year over year change by month for long haul dry van contract and spot rates from July 2013 to January 2021
Source: DAT FMIC (2021)

experienced during tight (capacity constrained) markets.

The remainder of this paper is organised as follows. First, we discuss the details of the US long haul full truckload trucking market. Its peculiarities need to be understood to make sense of the market fluctuations. Second, we introduce the traditional for-hire transportation procurement process that has been used by shippers for the last several decades. Third, we discuss weaknesses of this current process and demonstrate how much of the problem of the market lies with assumptions and practices within the procurement process. Fourth, we identify and discuss the practical implementation of several innovations that allow shippers to be more dynamic and agile. Finally, we conclude by talking about future directions of transportation procurement.

NATURE OF THE FULL TRUCKLOAD (TL) MARKET

The North American truckload transportation market is critical to the US economy. As the saying goes, all products move by truck at some point in their journey from initial origin to final destination. In North America, the majority of trucking is full truckload that moves from a single point of origin directly to a single destination. While this direct full truckload market seems simple, it is, in practice, exceptionally complex for six reasons.

First, the TL market is massive with annual revenues in excess of US$400bn representing over 2 per cent of the national GDP.[5]

Second, it is highly fragmented with hundreds of thousands of carriers, most of which are very small. The American Trucking Associations reports that 91 per

cent of truckload firms have six or fewer trucks while 97 per cent have fewer than 20.[6]

Third, it is highly competitive. To measure this, we can use the Herfindahl-Hirschman Index (HHI) which is used by the US Department of Justice to measure market concentration for anti-trust violations.[7] It is calculated as HHI = $\Sigma(s_i^2)$ where s_i = market share of firm i and therefore HHI approaches 0 when there are many companies in a market of about the same size and 10,000 when there is essentially a single firm with 100 per cent of the market. A highly concentrated market has an HHI > 2500 while unconcentrated markets have an HHI ≤ 1500. The TL market in 2019, for example, had an estimated HHI of just under six, that is, three orders of magnitude below the official definition of an unconcentrated market.[8] There are only minimal barriers to entry or exit in the TL market as well, further contributing to its competitiveness.

Fourth, every transaction involves at least two, and usually more, independent players with differing objectives and goals. Of course, every shipment requires a shipper and a receiver (consignee). These are the companies that own the product being moved at the origin and destination, respectively. For inter-plant or internal moves, the shipper and receiver might be the same company. Additionally, most truckload shipments involve the use of a third party: for-hire carrier. Some shippers have their own trucking assets or private fleets, but most also use for-hire carriers for the majority of their transportation needs. Finally, these transactions often involve brokers or third-party logistics providers (3PLs) that coordinate the transactions between shippers and carriers. Brokers provide value to shippers by providing them easy access to a large number of smaller carriers, and value to carriers by extending their ability to reach larger shippers they would normally not be able to work with.

Fifth, there is a very strong business cycle to the TL transportation market (see Figure 3). Power in the market flips back and forth between shippers and carriers on a roughly three-year cycle between tight (demand exceeds supply) and loose (supply exceeds demand) markets.[9] With power in the relationship alternating back and forth, it is difficult to establish relationships and contracts that span multiple cycles. The priorities and general behaviour of shippers, carriers and brokers change as the markets fluctuate.[10]

Finally, transportation is a derived demand. This means that forecasting future demand for truckloads is dependent not on trucking itself, but on the underlying demand of the goods being shipped.

These six factors combine to create a complex and challenging environment for shippers to procure for-hire transportation services. This partially explains why the standard procurement process for most shippers has settled into a rather complicated two-stage process — as described in the next section.

TRADITIONAL TRUCKLOAD TRANSPORTATION PROCUREMENT PROCESS

To understand the current state of TL transportation procurement, it is important to discuss deregulation. Prior to 1980, all surface freight transportation in the US was highly regulated. Trucking firms were required to obtain authorisation for hauling by both commodity and route. The process to obtain these

authorisations was both costly and time-consuming. Additionally, shippers with private fleets were not allowed to haul other shippers' freight and for-hire carriers were restricted to being either contract or common carriers. Common carriers could offer transportation to the general public but were required to charge the same 'reasonable' rates (tariffs) to customers with similar freight — that is, they could not discriminate between shippers. Contract carriers, on the other hand, could serve specific customers but were not allowed to carry general freight from other shippers. Also, the number of customers a contract carrier was allowed to serve was limited to eight (the rule of eight). The net effect of these rules was the protection of the existing motor carriers through extensive barriers to entry.

The Motor Carrier Act (MCA) of 1980 deregulated the inter-state motor carrier industry primarily by removing many of these barriers. Specifically, the authorisation process was liberalised to include only insurance coverage and safety standards; private fleets were granted authority to haul additional freight; for-hire motor carriers were allowed to operate dually as common and contract carriers; and the 'rule of eight' was removed. Contract carriers were now allowed to set individual rates for specific shippers as long as the rates were filed at the ICC. This filing requirement was also eventually retired as well by the Trucking Industry Regulatory Reform Act (TIRRA) of 1994.

Upon enactment of the MCA, there was an almost immediate entrance of small, entrepreneurial and primarily non-union carriers into the marketplace. The number of carriers registered with the Interstate Commerce Commission (ICC) rose from 16,874 in 1980 to 54,480 in 1994 and to over 300,000 in 2021.[11] While the total number of carriers dramatically increased, the growth was not uniform across all industry segments. The vast majority of the new entrants were in the direct full truckload segment where there were, and still are, essentially no barriers to entry or exit.

The major effect of deregulation on transportation procurement was to reintroduce competitive forces to an industry which had been protected for close to 50 years. Existing carriers now had to compete not only with these new entrants, but also with other established carriers ready to expand into other carriers' geographic markets. The general response of carriers across the board was to cut rates. While an apparent boon to the shippers, these rate wars lead to decreased profit margins and bankruptcies for many carriers. Finally, the distinction between common and contract carriers became irrelevant, so that more carriers were allowed to enter into contractual agreements with shippers. This increased the importance of negotiation in the transportation procurement process with shippers.[12]

For shippers, previously restricted to limited choices due to geographic monopolies, this became an embarrassment of options. There were more TL carriers available to haul their freight than ever before. Unfortunately, many, if not most, of these were very small regional carriers that they had not worked with before. The challenge for shippers at this stage became how to select the right carriers for their network from a bewildering number of unfamiliar alternatives. Additionally, the cost structures for TL carriers changed so much that even the carriers themselves did not necessarily know their own costs at the lane level — especially on those lanes that were new to them.

The challenge for shippers was now how to select carriers efficiently and effectively for each freight lane from many alternatives where the specific lane rate is not established (or even known to either the buyer or the seller) and most of the carriers are unknown to them. In situations like this, the best mechanism for both determining the price of a product (or service) as well as selecting the best choice among alternatives, is an auction. Or, more precisely, a reverse auction whereby the shipper (the buyer) auctions off the right to haul freight on its lanes (origin-destination pairings) to a large number of bidding TL carriers (the sellers).

And so, starting in the early 1990s, shippers started running annual reverse auctions of their freight lanes in order to select contract carriers for the upcoming year. While there are many forms of auctions available for shippers to choose from, most transportation procurement auctions were multiple round, sealed bids. Carriers were 'awarded' lanes on a lane-by-lane basis with the lowest cost carrier being awarded hauling rights on that lane for a period of time — typically a year. Of course, the participating carriers were typically subjected to financial and quality checks prior to being included in the auction itself.

As of the late 1990s these annual RFPs (request for proposals) became standard practice and transportation procurement evolved into the now common two-stage process: awarding and tendering. The awarding stage consists of an annual RFP that typically utilises sophisticated mixed integer and linear programming optimisation software to allocate lanes to carriers.[13,14] The effort spent to run an annual RFP is non-trivial. Analysis conducted by DAT revealed that the time required to prepare, conduct, analyse and implement the results of an annual RFP can range from 12 to 23 weeks with a median duration of 16 weeks.[15] The output of the annual RFP stage consists of an allocation of specific carriers to specific lanes, sometimes with forecasted volumes or maximum capacity levels. These assignments are then fed into the routing guide which is at the centre of a shipper's transportation management system (TMS). The routing guide is essentially a catalogue that lists the primary (winning) carrier on each lane with the runner-up (losing) bids from different carriers listed as backups for that lane.[16]

The second stage in the procurement process is the tender. This is when, during the course of a year, an actual shipment needs to move on a lane. The shipment enters the TMS, is matched via the routing guide to the primary carrier on that lane and is tendered to that carrier. At this point in time, the specific details of the shipment are known: the preferred time for pickup, desired delivery date/time, the specific locations etc., as opposed to during the annual RFP where the awarded volume is only a forecast of volume for that lane for the upcoming year.

Once a shipment is tendered to the primary carrier, they can either accept or reject it. If accepted, the carrier follows through and completes the transaction: scheduling a pickup, assigning a driver, dispatching a truck, etc. If rejected, however, the shipment goes through what is typically called a waterfall process within the shipper's TMS whereby it is offered to the first alternative or backup carrier in the routing guide. If they too reject, it is sequentially offered to each backup carrier in the routing guide in sequence. If at the end of this process the shipment has not been accepted by

any of the carriers in the routing guide, it typically moves to what is known as the spot market where it is offered to a number of carriers at the same time for a price to be negotiated for that specific shipment alone and not necessarily for any future loads on that lane. In practice, most shippers typically access the spot market through the use of a broker.

There are many deviations from this process, of course. Some shippers will offer their shipments to their private fleet prior to offering it to for-hire carriers. Other shippers will go directly to the spot market upon the primary rejecting it. In virtually all cases, however, they follow some sort of priority 'waterfall' process from contracted to backup to spot.

Another key point in truckload transportation procurement is that, unlike traditional contracts for most other products and services, truckload contracts are not fully binding. While they are binding in terms of price (say, US$1.90 per mile on a lane from Atlanta to Chicago), they are not in terms of the volume of freight that the shipper will eventually offer nor the capacity that the carrier will ultimately provide. There are rarely any financial penalties if the shipper's lane volume, as shown during the annual RFP, does not materialise or if the carrier does not provide a truck every time it was requested.

The 'looseness' of these contracts is required by the dynamic nature of the underlying TL market. As a service, truckload movements cannot be stored ahead of time — they are fleeting temporally and spatially. Instead, both shippers and carriers monitor how the other is performing throughout the course of the contract. If a carrier refuses too many tendered or offered shipments, then the shipper might remove them from this lane and, more damaging, from their entire network and ban them from any future work. If a shipper tends to not actually tender the volume awarded to a carrier in the annual RFP, then that carrier may increase rates for future business or simply stop providing capacity. Essentially, TL contracts are kept in place through the threat, or promise, of future business or capacity rather than direct financial penalties.

The dominant design of truckload transportation procurement since the mid-1990s has coalesced into the current two-stage process of awarding (from an annual RFP) and tendering (through the shipper's TMS and routing guide). This made total sense when it was introduced in the mid-1990s when the truckload market was still in flux and price discovery was critical. Even with the numerous improvements and enhancements to both the process and technologies made over the last several decades, however, the traditional two-stage procurement approach has remained fundamentally unchanged and is not suited to the dynamic nature of the current market. The last two tight market cycles (2017–18 and 2020–21) have clearly demonstrated that this dominant design is no longer sufficient. In order to understand what should replace the traditional process, we need to dive deeper into specific reasons why it is failing.

PROBLEMS WITH THE DOMINANT DESIGN OF TRANSPORTATION PROCUREMENT

There are two major flaws in the current dominant design of transportation procurement (annual RFP to routing guide). The first is that there is a technology gap between the tools used to assign carriers to lanes in the annual RFP

and those used in tendering a specific shipment to a carrier in the TMS. The bidding software tools used by shippers to allocate lanes to carriers are exceptionally sophisticated and can consider a wide range of factors when designing the final carrier assignment. These are essentially planning tools sitting on sophisticated optimisation engines that allow for hard constraints (eg ensure regional carriers are awarded at least 20 per cent of total volume or limit the total number of carriers to 30), soft trade-offs (eg favour incumbent carriers by 4 per cent or penalise carriers that do not provide real-time visibility by 6 per cent) and packaged or bundled awards (eg assign these five lanes to the same carrier in a package since they complement each other). With these tools, shippers are able to quickly and effortlessly generate dozens to hundreds of very detailed carrier assignment scenarios. Interestingly, even though bidding tools have improved over the last two decades, the time spent analysing the annual RFP results has not decreased. Instead, the ease of running these scenarios has led shippers to run more of them.

In comparison, the software used to select which carrier to tender a shipment to is, with very limited exceptions, very simple. The results of the annual RFP, regardless of the thought and intentions behind the very detailed carrier assignment, are fed lane by lane into a routing guide. All justifications and reasoning behind the assignment are lost; the only data saved in the routing guide are a lane-by-lane listing of the primary and backup carriers, their offered rates, and, sometimes, the average weekly volume noted in the annual RFP. The carrier selection within a TMS is designed for speed of operations — automating the process so shipments can be tendered as quickly as possible with minimal manual effort. So, while the annual RFP is like a scalpel used to craft a perfect carrier assignment, the routing guide in a TMS is more like an axe with very limited flexibility to handle any exceptions. The sophistication gap between bidding tools and TMS is a major challenge that shippers are trying to overcome.

The second, and more critical, shortcoming of the dominant design for transportation procurement is that it is, by design, a deterministic and static process while the underlying truckload transportation market is highly dynamic. Even as the bidding tools used in the annual RFP process have become more sophisticated, they have not advanced in terms of recognising the inherent uncertainty and variability of truckload transportation. This 'uncertainty blindness' manifests itself in three undesirable outcomes over the course of a year: unplanned lanes, out-of-budget lanes and ghost lanes.

An unplanned lane is a lane that was not included in the annual RFP, but had shipments tendered on it throughout the year. That is, these lanes were not planned to occur. This could be the result of new customers, changing product flows, new facilities or simply poor or incomplete planning. The problem is that because these loads do not have corresponding contract rates, they are subject to the whims of the market for establishing spot rates — usually with very short lead times.

Out-of-budget lanes are those lanes that are included in the annual RFP, but over the course of the year either the volume of loads far exceeds the planned level or the rate per shipment exceeds what was contracted during the annual RFP. This happens when the shipper has to rely extensively on backup carriers or the spot market to cover shipments

planned to be moved at the primary carrier's (typically) lower rate. Research at MIT's FreightLab has shown that backup rates average around 10 per cent higher than the primary carrier rates on a lane while spot rates average 20 per cent to over 30 per cent higher depending on the state of the market.[17]

Finally, ghost lanes are those lanes that were included in the annual RFP, but over the course of the contract life, shipments never materialise — or they are at substantially lower volume levels than suggested in the annual RFP. Most shippers have no idea of the percentage of lanes that end up being ghost lanes. Current MIT FreightLab research suggests that this can approach 50 per cent of the lanes awarded for some shippers.[18]

The technology gap between the transportation planning and execution tools combined with 'uncertainty blindness' leads to the major capacity challenges that shippers are facing today. Fortunately, these weaknesses have been recognised by shippers, carriers and brokers alike and have led to wider experimentation in how the three different players should work together. This is the topic of the next section.

INNOVATIVE APPROACHES TO TRANSPORTATION PROCUREMENT

Recognising the current shortcomings of the dominant design has led to the recent development and implementation of a number of innovative processes and technologies to improve shipper–carrier–broker relationships. We will discuss four innovative and promising trends: data-driven analysis, transportation portfolio management, dynamic contracting and continuous procurement.

Data-driven analysis

Freight transportation generates significant amounts of transactional data. Most TMSs only capture the information on each shipment required for payment and audit purposes. Namely, the origin, destination, assigned carrier and cost. This makes sense since TMSs are designed for fast execution — not for detailed exploratory analysis. Most systems currently neither collect nor retain useful information on transportation flows, such as dwell time, loading/unloading conditions and durations, carrier turn-downs, lead time, late arrivals, etc. Because of this gap in TMS functionality, a new category of cloud-based software has emerged to handle this analysis as an add-on to the traditional TMS, such as DAT benchmark analytics.

Analysis of the shipment transactions, beyond just prices and flows, has multiple objectives. At the operational level, the shipper can identify and quantify factors driving rate differences that can be used to justify changing entrenched business processes. For example, recent analysis has shown that lead time[19] as well as the configuration of lanes being put out to bid[20] impacts carrier rates on lanes.

At a strategic level, analysis allows shippers to recognise that not all transportation lanes behave the same way in terms of the rates paid (beyond the obvious effect of length of haul) or the probability of a primary carrier accepting a tendered load. Recent research by DAT, the MIT FreightLab and elsewhere, has shown that there are four key dimensions to the price and probability of carrier acceptance: total lane volume[21] (on a monthly or annual basis), volume variability[22] (for those weeks when loads are actually tendered), consistency[23] (the number weeks in a year when loads are tendered) and balance[24] (the level of

economies of scope across the lanes). As expected, higher total volume, lower volume variability and higher consistency all lead to lower rates and an increase in the likelihood of the primary carrier's acceptance.[25]

Each of these first three dimensions (volume, variability, consistency) are intrinsic properties of each lane for that shipper; however, the fourth dimension (balance) is a multi-lane property. It is related to economies of scope, meaning that the cost of serving a lane from A to B depends on the probability of easily securing a load out of B as well as a load into A. These are known as geographic or regional values. This explains why a TL shipment from Chicago to Miami will cost much more than a shipment in the opposite direction even though the distances are identical. The reason for the difference is due to the low volume of freight leaving Miami while that leaving Chicago is more plentiful.

At a national market level, these regional effects are a result of underlying macroeconomic factors and tend to change slowly over time with the exception of seasonality changes — especially for origins with significant agricultural output. Within a shipper's network, balance can be achieved if there are 'round trips' or a consistent and approximately even flow of shipments between facilities. We will discuss how to handle these opportunities using dedicated assets in the next section.

In addition to being able to characterise and analyse performance on their own lanes, the shippers need to be able to compare their rates to external benchmarks. This enables the shipper to better understand if their rates are out of range of the market and, if so, why. The ability to benchmark across other shippers is another argument for the use of a third-party cloud-based analysis tool. These benchmarks can be derived either by econometric modelling[26] or through sophisticated rate aggregation at the temporal and geographic levels.[27] The addition of data external to the shipper also allows for better predictive rate models which can be incorporated into making better procurement decisions. This will be discussed in a later section. The biggest benefit of better analysis and segmentation of lanes, however, is that it allows for better management through the use of portfolio management — discussed in the next section.

Transportation portfolio management

As noted in the previous section, transportation lanes do not all behave the same and therefore should be procured and managed according to their individual and interdependent characteristics. This suggests that a shipper should utilise a portfolio approach where 'relationship forms' are managed in a similar fashion as investment opportunities are within a financial portfolio. We can think of three major classes of relationships within a shipper's potential transportation portfolio: dedicated, contract and dynamic.

A *dedicated* relationship is where the shipper serves certain lanes with its own drivers and trucks as a private fleet or through a third party that provides its assets for a specific period of time. In either case, the shipper is responsible, and pays, for the asset utilisation. A *contract* relationship is where the rates and commitments are established through an annual RFP process for a set period of time. As mentioned earlier, the typical TL contracts are for a year and are binding in price, but not in volume provided by

the shipper nor capacity supplied by the carrier. Finally, a *dynamic* relationship is where the rate is negotiated and set on a load-by-load basis — that is, the commitment is for only one load at a time and there is no expectation, implicit or explicit, for future volume or capacity at this rate. This is often referred to as the spot market — but dynamic relationships cover a wider range of options and is a more accurate term.

Each relationship class within the portfolio is best suited to specific lane types that can be thought of as being on a continuum. At one end are consistent, reliable and balanced lanes that are best handled by dedicated relationships. At the other end of the continuum are highly variable, irregular, sparse, sporadic and unbalanced lanes that are more suited to dynamic relationships, whether through brokers, load boards or some other mechanism. Contract relationships cover the large number of lanes that fall between these two extremes. Segmentation of the lanes within a shipper's network requires the level of analysis described in the previous section in terms of volume, variability, cadence and balance.

Selecting lanes for dedicated or private fleet relationships is mainly an engineering exercise. The objective is to identify sets of lanes that have sufficient reliable, consistent and compatible volumes whereby trucks could operate with a low level of empty miles between loads. There has been a fair amount of research into how to establish dedicated operations.[28,29,30,31] In practice, we are seeing shippers apply this analysis more frequently than in the past in order to quickly adjust to shifting markets. Dedicated relationships tend to result in lower total transportation costs during tight markets but can potentially lead to higher costs due to poor utilisation during loose markets when for-hire capacity is readily available. A more recent development is the design and operation of shared dedicated fleets across shippers — although this has been attempted in the past with limited success, current technology appears to be more amenable.

Dynamic relationships have always been considered an anathema to shippers. As with any cost centre in a company, transportation managers crave rate stability and budget predictability. This has changed dramatically since 2016 with the emergence of what have been called e-brokers, digital freight matching,[32] or more commonly, digital freight brokers (DFBs). While performing the same role as traditional brokers, matching drivers to loads, these companies are typically venture capital funded and would describe themselves more as technology-focused than transportation-focused. While there is a lot of debate as to how, if at all, traditional brokers differ from these DFBs, it is hard to argue that they have not introduced more innovation and technology to the industry.

Primary among the contributions is their ability to supply dynamic pricing directly to a shipper within their TMS using what is known as an application programming interface (API). An API is simply software that allows two applications to communicate with each other directly. This is in contrast to the most common form of shipper-carrier communication, electronic data interchange (EDI) which is a more formal and rigid communication protocol that has been around since the 1970s. While exceptionally efficient once established, EDI requires extensive effort to set up a connection and is brittle to any changes. APIs, while still relatively new to the industry, are being adopted at a faster

pace by shippers, carriers and brokers alike and have additional benefits. Some DFBs are offering dynamic rates that are generated algorithmically based on the current state of the market. These rates can be embedded within the shipper's TMS as a default rate, as a rate of last resort, or part of an auto-tender routine.

Dynamic relations can also be used within what is referred to as a shipper's 'private network' or 'private marketplace'. This is where a shipper identifies a set of carriers that are offered shipments that are not handled by the primary or the backups in their routing guide for a set period of time. The established rate is only for that one shipment and not for any future moves. While there has been some activity at better defining and identifying opportunities for dedicated and dynamic relations, the most interest has been around improving contractual relations. This is discussed in the next section.

Dynamic contracts

The traditional TL contract (binding in price but not volume or capacity) was described earlier. While this is the most common form of contract, it is not the only form. In fact, several more innovative, technology enabled contractual relationships are emerging. Each of these requires a sophisticated TMS — the current Achilles' heel for most of these innovations. Each of the following contractual forms are suited to certain types of freight and require different forms of procurement and management. These are thought to complement, rather than replace, traditional contracts that are suitable for a large swath of shipper lanes.

- *Guaranteed volumes (take or pay)*: A contract on lanes where the shipper guarantees a set number of loads per day/week to a carrier at an agreed upon rate but pays a penalty if the agreed upon number of loads does not materialise.[33] The carrier, on the other hand, commits to 100 per cent acceptance of these shipments to include a certain percentage of volume above the guarantee — typically 10–20 per cent. These contracts are suited to high and consistent volume lanes that are not necessarily balanced within the shipper's network;
- *Guaranteed service lanes*: A contract where the carrier guarantees 100 per cent acceptance of all loads from the shipper on certain lanes at an agreed upon rate but retains brokerage rights for up to a certain percentage of the volume each week/month. This is essentially a hands-off policy for the shipper in that the carrier assumes all risk of volume changes and market fluctuations;
- *Volume tier-based pricing*: A contract whereby the shipper pays different agreed upon rates based on the number of loads tendered per time period, usually a week. A shipper might have three tiers of volume on a certain lane (eg < 10 loads, 10 to 15 loads and > 15 loads in a week) and the carrier will be paid a different rate for each tier volume (eg 1.50 US$/mile, 1.60 US$/mile and 1.70 US$/mile). Typically, the rate increases with the level of volume, which highlights the counterintuitive (to non-transportation executives) diseconomies to scale that truckload trucking has at the lane level. Tier-based pricing shifts some of the risk carriers face with surged volume on lanes to the shipper. It is, however, complicated to establish within a TMS as the price is now a function of the number of tendered loads per lane and carrier.

Additionally, carriers have historically found it difficult to price out the marginal increases with higher volumes;
- *Index-based pricing*: A contract where the shipper pays a carrier an agreed-upon rate for a lane. The rate is adjusted periodically, however, based upon some mutually agreed upon external index.[34] Index-based rates are designed to encourage both parties to honour the contracted rates in both tight and loose markets. There is considerable discussion on what index to use, how frequently to update the rates, whether the adjustment is symmetric and other design details.

This is just a short sampling of the different types of contractual forms that shippers, carriers and brokers are exploring. In each case, the contractual form tries to minimise some aspect of risk to one or more of the different parties. Also, these more sophisticated contractual forms require not only additional data analysis and segmentation, but also potentially significant modifications to the underlying TMS. The payment and audit functionality, in particular, becomes much more complicated. Finally, it should be obvious that these contracts should complement rather than replace the existing common form.

Continuous procurement

The final recent development we will discuss is the idea of continuous procurement throughout the year rather than relying solely on an annual RFP. While both shippers and carriers actively complain about annual RFPs, very few see it phasing out completely. The reliance on the annual RFP is definitely declining, however, as it produces a static solution to a dynamically changing problem. It has become just one of many tools in the toolbox for procurement — albeit a very big and important tool.

The frequency of procurement events for contracted rates has been increasing over the last few years (see Figure 4). It shows the number of new contract lane rates entering a specific shipper's routing guide from 2016 to the end of 2020 by day. For example, in 2016, 240 new contract rates were introduced on one day. The timing of the annual RFPs is easy to identify for 2016, 2017, 2018 and 2019 by the sharp spikes. Note, however, the increase in the number of days with more new rate entries in 2019 and especially in 2020. These are not spot rates, but rather new contract lane rates for future shipments. This particular shipper introduced 100 or more new contract rate lanes in 44 of 52 weeks in 2020 while over the previous four years this occurred fewer than 20 weeks per year.

Figure 5 shows the number of weeks when a certain number of lanes were procured and entered into the shipper's routing guide as contract rates for a shipper from 2012 to 2020.[35] The weeks were bucketed into four categories: none, 1 to 25, 26 to 250, and over 250. So, for example, in 2014 we can see that in 20 per cent of the weeks no new lane rates were procured, in ~60 per cent of the weeks had 1 to 25 lane rates procured, ~12 per cent of the weeks had 26 to 250 lanes procured and the remaining 8 per cent of the weeks had more than 250 lane rates procured. An obvious trend is that the number of weeks where a bidding event did *not* occur has been decreasing over time.

Holding more frequent 'off-cycle' procurement events allows shippers and carriers to be more dynamic. These off-cycle events are commonly called mini-bids and they differ from annual RFPs in several important ways. First,

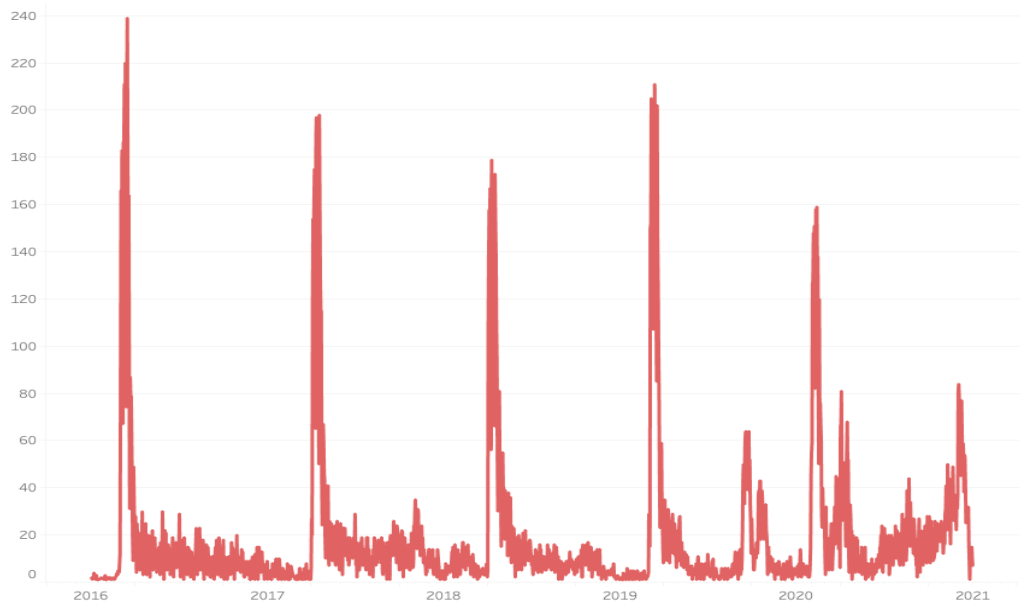

FIGURE 4: The number of first contract rate lanes entering into a shipper's routing guide by day from 2016 to the end of 2020. The peaks represent annual RFPs. Note the dramatic increase in the frequency of new contract rates entering during 2020
Source: DAT FMIC

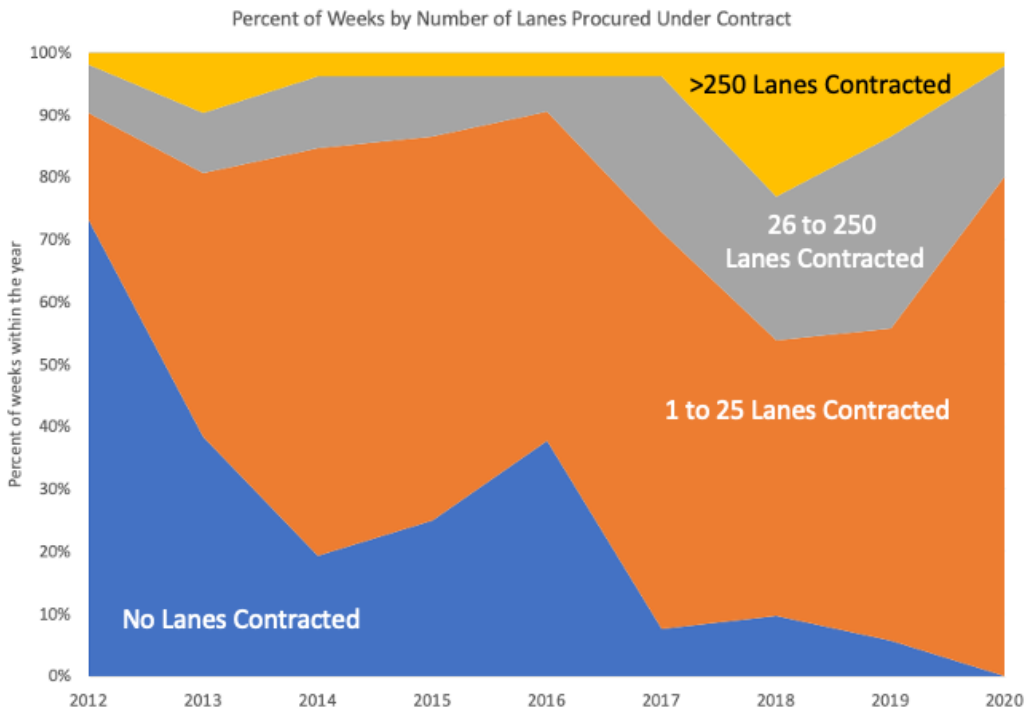

FIGURE 5: The percentage of weeks in each year from 2012 to 2020 in which a specific number of lanes were procured and entered into the routing guide as contract rates for a shipper
Source: MIT FreightLab

the objective of the annual RFP (explore widely and find the carriers with the best cost/level of service fit for your network) is very different from that of a mini-bid (find reliable capacity as fast as possible). Second, mini-bids are much smaller, more focused and therefore take less time for shippers to compile and for carriers to respond to than annual RFPs. Third, the auction format used in mini-bids is simpler. While most shippers employ multiple round auctions for the annual RFP, single round is dominant for mini-bids. Again, the focus is on speed to securing capacity. Fourth, annual RFPs can involve major network changes, such as setting up trailer pools, while mini-bids are used to quickly secure rates on existing or recently added lanes. Fifth, contracts coming out of mini-bids are typically shorter in length than those from an annual RFP — lasting typically until the next scheduled annual RFP. Finally, the cycle time from rate submission to implementation in the routing guide is much shorter for mini-bids (one to two weeks) than annual RFPs (one to three months).

The addition of new lanes to a shipper's network is an obvious trigger to run a procurement event; however, there are two other cases that justify a mini-bid. The first is when a carrier is failing on a lane — whether by not providing the requested capacity or asking for rates higher than the shipper is willing to pay. The second is when a shipper thinks they can get better contract rates in the current market. These two reasons are caused by tight and loose markets, respectively, and get to the issue of reciprocity and level of trust between shippers and carriers.[36] Shippers are becoming more sophisticated in how and when they should run a mini-bid. Some possible triggers include a surge in demand above what the current carriers committed to, changes to the supply chain and volatility in market rates. Data-driven analysis of a shipper's network, as discussed in the previous section, can be used to identify early indicators of carrier failure. Similarly, having active and current market benchmark rates at the lane level can be used for triggering any opportunistic mini-bids.

The four trends discussed in this section are not mutually exclusive. Instead, they interact with each other. Data-driven analysis on shipments, lanes and rates is required to intelligently segment lanes to be procured and managed using different relationship forms (ranging from dedicated to contract to dynamic) within a transportation portfolio. Better analytics within a TMS also enable the use of more sophisticated and responsive contractual forms, such as indexed or tiered pricing. Finally, real-time data analytics of current internal and market conditions can be used to trigger off-cycle procurement events or mini-bids. An even more interesting approach is for the shipper to develop a proactive playbook that combines on-going analysis and real-time forecasting with a suite of proactive managerial actions, such as renegotiation or running a mini-bid. This concept was developed for a large manufacturer as a test and offers great potential in improving the responsiveness and agility of a shipper in securing sufficient truckload capacity.[37]

CONCLUSIONS AND FUTURE RESEARCH

This paper discusses the current challenge that shippers are facing concerning securing sufficient truckload transportation capacity. Because of market and historical reasons, the current dominant design for truckload transportation procurement is a two-stage approach.

The first stage involves using a reverse auction with sophisticated optimisation tools to award haulage rights on lanes to carriers for a long period time, typically a year. The second stage occurs when a shipment materialises over the course of the year and the shipper tenders it to the primary carrier (the one that won the auction) on that lane. While this methodology was appropriate when cost structures were not known with certainty by either shippers or carriers, it is no longer the case. This dominant two-stage design creates plans that cannot be executed on in real time by most TMSs and are unresponsive to changing market conditions. The last few years have shown that the market is highly dynamic and that this static approach is no longer appropriate.

We discussed four promising approaches for improving the shipper–broker–carrier interface: data-driven analysis, transportation portfolio management, dynamic contracts and continuous procurement. While each has potential individually, the true power is in their combined use. Data-driven analysis of networks — both of internal flows and rates as well as external market forecasting — allows a shipper to better segment its network and procure capacity using a variety of relationship forms within a balanced transportation portfolio. The portfolio can be expanded through the use of dynamic contractual forms which, in turn, can be used continuously to proactively take steps to guarantee sufficient truckload capacity for the shipper.

There are several areas of research worth pursuing further. More sophisticated analysis and forecasting of transportation rates and flows is sorely needed. Advanced machine learning (ML) techniques are starting to be applied to transportation but there is still significant opportunity for improvement. While the three major classes of relationship forms were identified (dedicated, contract, dynamic), there is great need to be able to better segment networks appropriate for these different relationship forms. Shippers are just beginning to explore how and where to use dynamic relationships strategically rather than as a last resort. The integration of dynamic rates into a transportation budget, for example, is an area worth exploring. Dynamic contract types are fertile ground for both theoretical and empirical studies. The repeated games format of shipper–carrier relations is a perfect environment for testing and piloting different relations and forms. Index-based pricing in particular offers great potential.

While truckload transportation has been studied for several decades, the real-time implications, procurement and management is a new field to explore that has both academic as well as practical implications.

REFERENCES

(1) Smith, J. (February 2021), 'Trucking Failures Surged Last Year Under Pandemic', *Wall Street Journal*, available at https://www.wsj.com/articles/trucking-failures-surged-last-year-under-pandemic-11612827527 (accessed 2nd March, 2021).
(2) Cassidy, W. (February 2021), 'US truckers suffering "bid fatigue"', *Journal of Commerce*, available at https://www.joc.com/trucking-logistics/trucking-freight-brokers/us-truckers-suffering-%E2%80%98bid-fatigue%E2%80%99-transplace_20210203.html (accessed 2nd March, 2021).
(3) DAT Load Board.
(4) DAT FMIC Market Consortium reports.
(5) AT Kearney (2020), 'Annual State of Logistics Report', Council of Supply Chain Management Professionals.
(6) ATA Economics and Industry Data, available at https://www.trucking.org/economics-and-industry-data (accessed 2nd March, 2021).
(7) Department of Justice, available at https://www.justice.gov/atr/

herfindahl-hirschman-index (accessed 2nd March, 2021).
(8) Transport Topics (2020) 'Top 100 Truckload Carriers', available at https://www.ttnews.com/top100/tl/2019 (accessed 2nd March, 2021).
(9) Pickett, C. (2018), 'Navigating the US truckload capacity cycle: Where are freight rates headed and why?', *Journal of Supply Chain Management, Logistics And Procurement*, Vol. 1, No. 1, pp. 1–18.
(10) Acocello, A., Caplice, C. and Sheffi, Y. (2020), 'Elephants or goldfish?: An empirical analysis of carrier reciprocity in dynamic freight markets', *Transportation Research Part E: Logistics and Transportation Review*, Vol. 142.
(11) Department of Transportation (2020), 'Pocket Guide to Large Truck and Bus Statistics', Federal Motor Carrier Safety Administration.
(12) Caplice, C. (1996), 'An Optimization Based Bidding Process: A New Framework for Shipper-Carrier Relationships', unpublished dissertation, Massachusetts Institute of Technology.
(13) Caplice, C. and Sheffi, Y. (2003), 'Optimization Based Procurement for Transportation Services', *The Journal of Business Logistics*, Vol. 24, No. 2, pp. 109–128.
(14) Caplice, C. and Sheffi, Y. (2006), 'Combinatorial Auctions for Truckload Transportation', in Cramton, P., Shoham, Y. and Steinberg, R. (eds), *Combinatorial Auctions*, MIT Press, Cambridge.
(15) DAT Freight & Analytics (August 2020), 'Shipper Roundtable'.
(16) Caplice, C. (2007), 'Electronic Markets for Truckload Transportation', *Production and Operations Management*, Vol. 16, No. 4, pp. 423–436.
(17) Aemireddy, N. R. and Yuan, X. (2019), 'Root Cause Analysis and Impact of Unplanned Procurement on Truckload Transportation Cost', Management Engineering in Logistics Thesis, MIT.
(18) Liu, Y. X. and Miller, A. C. (2021), 'Should Shippers Be Afraid of Ghost Freight? An Empirical Analysis of a Customer Portfolio From TMC, a Div. of C.H. Robinson', Master of Applied Science in SCM Capstone, MIT.
(19) Caldwell, E. R. and Fisher, B. C. (2008), 'The impact of lead time on truckload transportation rates', Management Engineering in Logistics Thesis, MIT.
(20) Collins, J. M. and Quinlan, R. R. (2010), 'The impact of bidding aggregation levels on truckload rates', Management Engineering in Logistics Thesis, MIT.
(21) Harding, M. (2005), 'Can Shippers and Carriers Benefit from More Robust Transportation Planning Methodologies?', Management Engineering in Logistics Thesis, MIT.
(22) Kim, Y. J. (2013), 'Analysis of Truckload Prices and Rejection Rates', Management Engineering in Logistics Thesis, MIT.
(23) *Ibid*., ref. 19.
(24) *Ibid*., ref. 12.
(25) Scott, A., Parker, C. and Craighead, C. (2017), 'Service Refusals in Supply Chains: Drivers and Deterrents of Freight Rejection', *Transportation Science*, Vol. 51, No. 4, pp. 1086–1101.
(26) *Ibid*., ref. 10.
(27) DAT (2021), 'Rateview Product Sheet', available at https://www.dat.com/freight-rates/rateview (accessed 2nd March, 2021).
(28) Guastaroba, G., Mansini, R. and Speranza, M. G. (2009), 'Modeling the pre-auction stage: The truckload case', in *Innovations in Distribution Logistics*, Springer, Berlin, pp. 219–233.
(29) Caplice, C., Jauffred, F., Bright, M. and Disney, M. (2011), 'Optimal Transportation Portfolio Management at Walmart Stores', MIT Project Summary.
(30) Lee, T. W. and Po, R. (2007), 'Optimizing the Use of Dedicated and Contract Transportation Assets to Maximize Total System Profit', Management Engineering in Logistics Thesis, MIT.
(31) Mulqueen, M. J. (2006), 'Creating transportation policy in a network that utilizes both contract carriers and an internally managed fleet', Management Engineering in Logistics Thesis, MIT.
(32) Armstrong & Associates (2016), 'Digital Freight Matching: Capturing Technology-Based Efficiencies in the Trucking Industry', available at http://www.3plogistics.com/wp-content/uploads/2018/07/Digital-Freight-Matching_Participant-Report-Sample.pdf (accessed 2nd March, 2021).
(33) Andleigh, P. and Bullock, J. S. (2017), 'Balancing product flow and synchronizing transportation', Management Engineering in Logistics Thesis, MIT.
(34) Atmaja, S. and Thykandi, R. (2019), 'Alternate Pricing Model for Transportation Contracts', Management Engineering in Logistics Thesis, MIT.
(35) Current MIT FreightLab research.
(36) *Ibid*., ref. 10.
(37) Sokoloff, D. and Gaohui, Z. (2020), 'Predicting and Planning for the Future: North American Truckload Transportation', Management Engineering in Logistics Thesis, MIT.