Received: 1 November 2021 | Revised: 1 December 2022 | Accepted: 13 December 2022

DOI: 10.1111/jbl.12333

SPECIAL ISSUE ARTICLE

WILEY

Research on truckload transportation procurement: A review, framework, and future research agenda

Angela Acocella[1,2] | **Chris Caplice**[1]

[1]MIT Center for Transportation and Logistics, Cambridge, Massachusetts, USA

[2]Tilburg University School of Economics and Management, Tilburg, The Netherlands

Correspondence
Angela Acocella, MIT Center for Transportation and Logistics, Cambridge, MA, USA.
Email: acocella@mit.edu

Abstract

The body of literature on truckload (TL) transportation procurement decisions by firms (shippers) and their transportation service providers (motor carriers) has been driven by real-world challenges faced by a large and important segment of the economy. The field has received the attention of researchers from a wide range of domains. While this attention demonstrates the appeal of these complex procurement problems, it also underscores a key challenge: the literature is dispersed and uncoordinated. This makes it difficult to identify meaningful new streams of research, risks slowing progress in the field, and limits the exposure of the research to wider supply chain audiences. With this review of the existing literature, we coordinate the growing set of research in this domain and demonstrate how the TL procurement literature is positioned within the broader streams of service procurement research. We develop a framework that describes the types (make vs. buy) and timing (strategic or execution stage) of decisions about the procurement of TL transportation services, organized by which actor's perspective is taken—the shipper's or the carrier's. We suggest areas of future research informed by an existing set of industry-led research and the gaps we have identified in the academic literature.

KEYWORDS

auction, contracting, make vs. buy, procurement, spot market, truckload transportation

INTRODUCTION

Following deregulation of the US trucking industry after the Motor Carrier Act of 1980, the decisions firms (shippers) make regarding whether and how to procure transportation services from providers (motor carriers) have been the subject of a wide range of research. Interest in the topic is due in part to the immense impact the trucking industry has on the US economy: Over-the-road transportation comprises about 70% of total US freight movements by revenue (AT Kearney, 2021).

Deregulation bifurcated the for-hire trucking industry into less-than-truckload (LTL) and full truckload (TL) segments. LTL consists of movements of partial loads that are consolidated and moved together through a network of hubs and crossdocks, while TL consists of moves from a single point of origin directly to a single destination.

We focus on the procurement of TL services and the related decisions made by shippers and carriers in the United States. While this scope may seem quite narrow, there is a rich set of literature on the topic. Moreover, the TL industry is intriguing, as it is massive, with annual revenues of over

$700 billion compared to $80 billion for LTL (Council of Supply Chain Management Professionals, 2022); is highly fragmented, with hundreds of thousands of mostly small carriers (Federal Motor Carrier Safety Administration, 2021); is highly competitive, with a Herfindahl–Hirschman Index three orders of magnitude below the official definition of an unconcentrated market (Caplice, 2022); and typically involves multiple players in every transaction. In large part, research on TL transportation procurement has been driven by the complexity and novelty of the challenges that arise in practice, particularly because they are both spatial and temporal in nature. Compounding supply and demand uncertainties as well as ever-changing business cycles further complicate these issues.

Over the last 40 years, research on TL procurement has addressed a wide range of topics and employed a variety of methodologies. However, the existing body of literature is disaggregate; that is, it is disconnected and tends to be siloed. As a result, new research does not have a cohesive body of literature to reference, build from, and justify critical assumptions. We address this shortcoming by developing a framework to organize the TL procurement literature based on the types of decisions that the actors must make, at what point in the interaction the decisions are made, and which actor's perspective the research takes.

We offer four contributions from this review. First, existing studies of TL procurement are largely disconnected, which has left unavoidable gaps. Our review identifies these areas. Second, by developing our framework and compiling and analyzing the topics and perspectives across the disaggregate studies, we offer both new and experienced scholars a comprehensive way to position their research relative to other work in the field. We also offer a centralized source of literature for researchers from different domains and theoretical perspectives to identify research related to their specific freight transportation focus, better demonstrate the importance of their work, strengthen justifications, and identify weak points prior to peer review. Moreover, we demonstrate how TL transportation procurement fits into the broader procurement literature to help researchers convey the transportation field's contributions to a larger audience.

Our third contribution benefits journal editors and reviewers. Our study offers a source for reviewers not already expert in this domain to familiarize themselves with the existing literature, and thus more easily identify submitting authors' contributions. Finally, we outline a set of opportunities and directions for future work that have potential for high practical and theoretical impact. To do so, we identify the gaps in the existing body of academic literature and assess industry-driven white papers on topics practitioners value. We also offer specific research questions that may have implications for the procurement literature as a whole.

FRAMEWORK

The research on TL procurement can be broadly described along three dimensions. The first dimension is the decision that must be made: whether to vertically integrate the transportation function or to outsource it to a for-hire service provider—that is, the "make or buy" decision. The second dimension is when the decision must be made: whether it is a strategic- or an execution-level decision. Figure 1 shows the framework for the decision choice and its timing, or stage. The third dimension is which actor's perspective the research takes: whether the shipper or the carrier is making the decision. The decision sequence is depicted in Figures 2 and 3, which we describe in detail below.

Decision: Make vs. buy

A common sourcing choice in the supply chain literature is a firm's decision to vertically integrate the production of a good or service or to outsource that process and purchase it from a supplier. Shippers face this decision for TL transportation services as well.

Shipper–carrier relationships are positioned along a spectrum of forms (see Figure 3). At one extreme are private and dedicated fleets. In this relationship, the shipper manages its transportation needs through vertically integrating its own, in-house fleet (private) or with some fixed amount of an external carrier's fleet that is at the shipper's disposal (dedicated). At the other end of the spectrum are spot interactions. These exchanges are for a single-load transaction, typically, but not always, as a backup option when the shipper cannot otherwise find capacity. In the middle of the spectrum are the for-hire contractual relationships between shipper and carrier that cover certain segments of a shipper's network for a specified period of time.

In the make or buy decision, shippers must consider the trade-offs between the greater control and high level

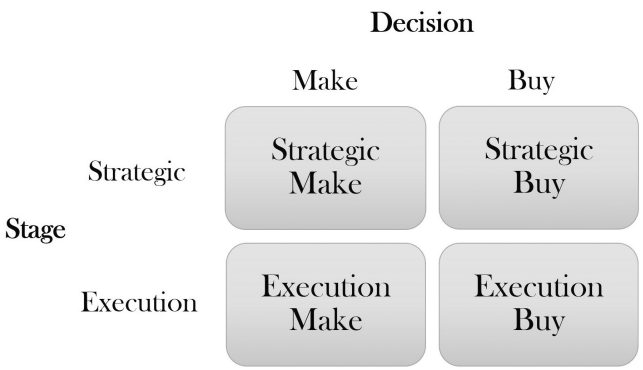

FIGURE 1 Framework of decision and timing.

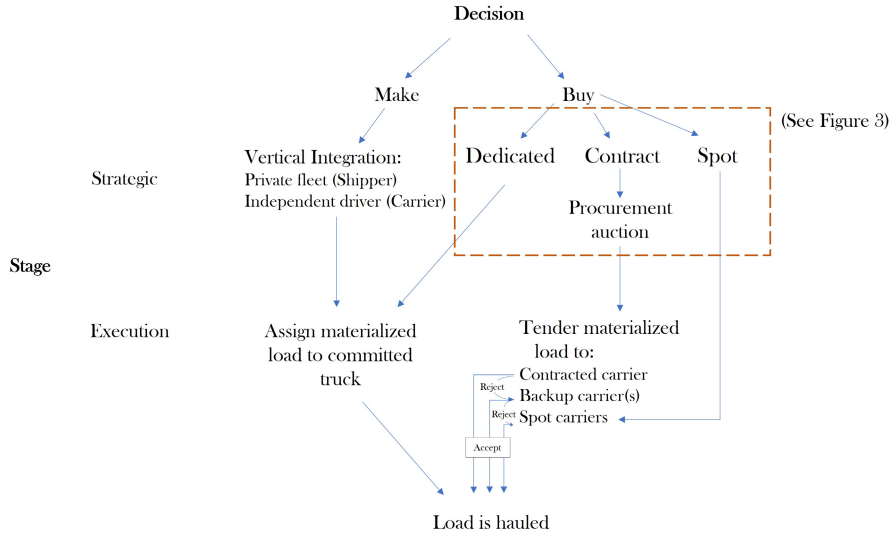

FIGURE 2 Decision sequence by stage.

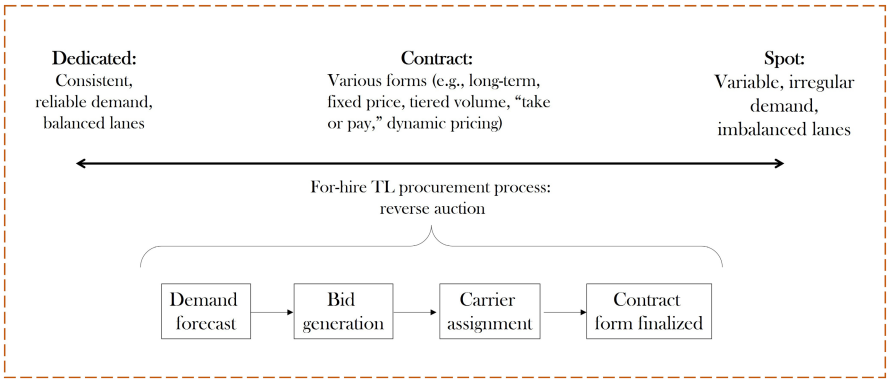

FIGURE 3 Shipper's strategic buy decision process.

of service typically achieved by vertically integrating the TL transportation service, and the reduced costs and improved system-wide efficiencies typically achieved by outsourcing. Most shippers engage in a combination of the three relationship forms for different network segments and must decide where and when to use them. Carriers, by contrast, have the mirrored perspective: the "make" decision refers to whether the carrier offers integrated services as dedicated capacity to a shipper. Carriers' "buy" decision, then, is to sell services through a contract or as spot transactions to shippers. Offering third-party logistics (3PL) or brokerage services also falls under this "buy/sell" decision for carriers.

Stage: Strategic or execution

The second dimension of TL procurement is the timing of the decision: either at the strategic, planning stage or the operational, execution stage. The shipper can decide to cover its transportation needs with in-house private transportation services (i.e., make), or buy from an outside supplier at both of these points in time. In the latter buy decision, the shipper can procure transportation contracts for future shipments (i.e., strategic buy) or for a single shipment at a time (i.e., execution buy). Our review demonstrates that the overwhelming majority of research and practitioner interest over the last several decades has involved the strategic, rather than the execution, buy.

For the strategic buy process, the shipper typically runs a reverse auction to procure contracted capacity for a specified period of time, typically 1 year. The carrier must determine its reservation price for each lane (origin–destination pair) it is interested in serving and then submit bid prices. This is referred to as the bid generation problem in the literature; see, for example, Caplice and Sheffi (2006), Lee et al. (2007), and Song and Regan (2005). The carrier's objective is to maximize profit across a network of shipper customers subject to network fit and capacity constraints. The studies in this domain build from those on auction theory, transaction

cost economics, algorithmic pricing, multi-attribute decision analysis, and supplier selection.

Once the carriers' bid prices have been collected, the shipper selects the carriers with which it will contract on each lane. This is known as the winner determination problem or the carrier assignment problem (Caplice and Sheffi (2006) and Guo et al. (2006)). The shipper wants carriers to bid as close to their reservation prices as possible—that is, the lowest price they are willing to accept to serve the demand *while maintaining the shipper's desired service levels*. This last point becomes important during the second stage of for-hire TL transportation.

The auction process results in contracts between the shipper and for-hire TL carriers. A unique and defining aspect of TL contracts in the United States is that while they are binding in price, they are non-binding in the amount of business tendered from the shipper or the supply of capacity provided by the carrier. This is due, first, to the difficulty for shippers to predict precisely when and where each load will need to be moved (which is determined by the timing of their own customers' orders), and second, to the difficulty for carriers to know with certainty that a truck will be available at the specific time and location each load does materialize. Since neither side wants to be penalized for uncertainties that are out of their control, TL contracts are flexible in this way.

The non-binding nature of TL contracts comes into play during the second, execution stage of TL transportation: the shipper's load tendering and the carrier's acceptance decisions (Figure 2). On the shipper's side, typically, during the strategic procurement stage, they communicate an expected or forecasted volume for a lane over the course of the contract. This is also referred to as the awarded volume. In fact, after deregulation, the law required that a "series of shipments" that often quantified an expected minimum, maximum, or range of tenders be included in the contract terms (US House of Representatives, 1993). This requirement was later abolished.

Since the repeal of that regulation, shippers do not have to indicate an expected volume in their freight contracts (see, e.g., a sample contractual motor carrier service agreement offered by the American Trucking Associations (2004)). However, even when there is an awarded volume, shippers may not tender the expected demand to the carrier. In some cases, only a fraction of the business the shipper had forecast during the procurement auction on specific lanes may actually materialize. In other cases, much more demand than anticipated may materialize.

On the other side, carriers manage large, complex transportation networks; they cannot realistically know that a truck will be available at the precise time and location each load needs to be moved. Accordingly, it is understood that carriers have to reject some portion of load tenders. To account for the forecasting uncertainty from shippers and the location- and time-specific challenges of dynamic capacity planning for carriers, both sides accept that TL contracts are non-binding in terms of volume promised and capacity provided.

Carrier rejections can have cost implications for shippers. If a contracted carrier rejects a load and the shipper must rely on backup carriers, it may pay 9%–35% more than the original contracted price on that lane (Acocella et al., 2020). For this reason, shippers want to ensure that their contracted carriers maintain high acceptance rates. However, the costs resulting from load rejections are not high enough to justify the legal costs to pursue court enforcement of the contract (Scott, 2015).

The most common contract form is the long-term, fixed-price contract, typically in effect for 1–2 years (Caplice, 2007). However, alternative contract forms have been explored in practice—and, to a lesser extent, in the literature. Examples include tiered volume pricing (a different price for loads above the awarded volume), "take or pay" (shipper pays for a fixed amount of capacity whether it is used or not), and flexibly priced contracts (Acocella et al., 2022a; Brusset, 2009a; Caplice, 2022; Tibben-Lembke & Rogers, 2006; Tsai et al., 2011).

During the execution stage, the shipper may also choose to procure capacity on the spot market, either as a backup when contracted carriers reject loads, or as a first choice if no contract exists on that lane. Spot transactions are typically single-load interactions, and the price is determined at the moment of execution.

The carrier's stages mirror those of the shipper. Carriers can offer dedicated or contracted services to shippers at the strategic stage. At the execution stage, carriers can offer their available capacity by accepting contracted load tenders through existing contracts or on the spot market.

Perspective: Shipper or carrier

Studies of the TL procurement process can take one or more perspectives, depending on which party is the focus of the research and its implications. For instance, the research objective may be to help the shipper improve procurement processes and outcomes. Or the objective may be to offer insights to help carriers make appropriate decisions.

While we make a distinction between asset-based carriers (trucking companies that own the equipment they use to transport goods) and brokerage services that do not own physical assets (sometimes referred to as third-party logistics [3PL] services), they are grouped together as the carrier perspective. One of carriers' decisions is whether

to offer asset-only services, brokerage-only (i.e., non-asset) services, or both. In the TL industry, brokers provide matching services between shippers and asset-based carriers. Shippers contract with brokers for future capacity, and when a load materializes, the broker finds a carrier to haul it.

Authors may focus on one or more than one actor's perspective. An example of the latter would be identifying the contractual terms under which both shipper and carrier attain optimal outcomes.

NEED FOR REVIEW

Procurement requirements have become increasingly challenging (Choy & Lee, 2003; Dumond, 1994; Ellram & Krause, 1994; Lawson et al., 2008) as they have evolved to a strategic business decision (Hong & Kwon, 2012). In the broader procurement literature, however, procurement of services is largely underresearched (Heinis et al., 2022; Hong & Kwon, 2012; Kleemann & Essig, 2013; Molin & Åge, 2017). Li and Choi (2009) argue that service procurement can be more challenging than procurement of manufactured products due to the dynamic nature of the interactions between buyer and service provider.

The procurement of transportation services is particularly complex due to the non-binding nature of TL contracts, and to the absence of legal ramifications for noncompliance. This stems, in part, from the prohibitively high court costs associated with such cases. While these factors set TL transportation procurement apart from the procurement of many other products and services, the TL context offers a unique opportunity to study certain aspects of procurement highlighted in the more general literature streams. Heinis et al. (2022) suggest that service procurement can be classified into a set of research domains. Four of these domains are especially pertinent to TL transportation: governance (the "make" vs. "buy" decision), purchasing approach (the reverse auction), supplier selection (the winner determination problem resulting in carrier assignment to lanes), and performance management (the execution stage of transportation).

We recognize the need for a review such as ours because the research streams that focus on the strategic and execution stages of TL procurement have largely been disconnected from each other. We are aware of two literature reviews similar to ours. Both have added value to the transportation community; however, they are narrow in scope and only partially address the breadth of research we identify here. Specifically, they consider neither the spectrum of shipper–carrier relationship forms (Figure 3) nor the second stage of TL transportation (Figure 2).

The first study, Basu et al. (2015), covers the extensive literature on the procurement of for-hire TL transportation: the bid generation and carrier assignment processes included in the first stage described above. However, the study overlooks the literature on the second stage and its ramifications. Moreover, the review does not include the literature on the variety of contract forms that result from the strategic stage, nor does it consider non-contractual relationships such as spot transactions (Lindsey & Mahmassani, 2015; Scott et al., 2017; Scott, 2018); or private or dedicated capacity agreements (Guastaroba et al., 2009). In addition, it only covers a limited period, from 2000 to 2014. Thus, it does not consider the two decades of literature following motor carrier deregulation, nor does it consider the industry's evolution toward digital services over the last decade.

The second review, Lafkihi et al. (2019), is limited in scope in some aspects, yet overly broad in others. The authors focus on the first stage, specifically for e-commerce applications. Moreover, they do not limit their investigation to the TL transportation industry, but rather, expand their literature review to include less-than-truckload, rail, air, and water freight transport as well. However, the procurement mechanisms, incentives, pricing structures, supplier characteristics, and processes differ dramatically across these modes.

This brings us to the importance of our contribution: a review of the literature on both strategic- and execution-level TL procurement processes. The existing literature is vast but disconnected; researchers have approached different aspects of these relationships with a variety of methods. Our review expands on the previous reviews' sole focus on the strategic stage processes (i.e., bid generation and winner determination problems) to also consider the outcomes of bids—the contractual relationship forms and the decisions made at the execution stage.

In addition, we consider literature on TL procurement decisions and relationships that are not governed by contracts: the spot interactions and the dedicated or vertically integrated private fleets (i.e., the "make" decision). Finally, we consider which perspective—the shipper's or the carrier's—is taken by the papers we review. This helps to further organize the disparate set of literature. By explicitly considering the nuances described above, we provide a useful source for practitioners and researchers interested in related research streams outside the field of transportation procurement, including load matching, mode selection, route planning, and dynamic pricing.

REVIEW METHODOLOGY AND SELECTION CRITERIA

We conduct a systematic literature review, as laid out by Durach et al. (2017) and Short (2009). Our process is as follows: (1) define our research questions and framework,

(2) determine the journal inclusion and exclusion criteria, (3) find the potentially relevant literature, (4) select the literature according to the inclusion/exclusion criteria, (5) summarize the literature utilizing the defined framework, and (6) report on and apply the results.

We begin by formulating our research questions. RQ1: What gaps exist in the extant TL procurement literature leading up to and following deregulation? RQ2: What future research areas can be identified based on those gaps and emerging industry trends?

Because the transportation literature at large deals with questions, decisions, and aspects of transportation that are largely unrelated to one another, we must be clear with our review scope. For example, we explicitly exclude transportation research on topics such as safety (Douglas, 2021), traffic (Tyagi et al., 2009), infrastructure (Gillen, 1996), policy (Marsden & Reardon, 2017), sustainability (Ellram & Murfield, 2017), routing (Powell & Sheffi, 1983), and mode choice (Meixell & Norbis, 2008). Moreover, we do not include the small set of literature that considers the contractual relationships between carriers and their hired drivers Baker and Hubbard (2003) and Lafontaine and Masten (2002). Even after these exclusions, our review contains a large number of papers on a range of topics related to TL transportation procurement decisions.

Next, we define four inclusion/exclusion criteria to determine which journals to consider. First, we include those identified as highly ranked supply chain journals by the collection of top supply chain researchers, SCMList.com (SCM Congress, 2022). These journals are chosen based on their placement on lists reported by top-ranked supply chain and economics organizations such as *The Financial Times* and the University of Texas (UT) Dallas, or those that are published by leading supply chain management professional associations, including Association for Supply Chain Management (ASCM, formerly APICS), Council of Supply Chain Management Professionals (CSCMP), Decision Sciences Institute, and Institute for Supply Management (ISM). Second, we consider the journals on the list included in "Publication Productivity in the Supply Chain Management Discipline: 2011–2013" published in *Transportation Journal* (Maloni et al., 2015).

Third, we include top transportation journals from the Web of Science's Master Journal List (searched in 2022), filtering to include journals under the topic of Transportation and Transportation Science. We rank these journals by impact factor (scored by Clarivate and reported by the Web of Science) and take journals in the top 50% of the rankings. We then search for papers that include TL procurement and make/buy as part of the title, keyword, subject, or topic (Web of Science Group, 2022). The fourth list of journals includes the "Top 5" economics journals according to the American Economic Association (American Economic Association, 2020). Next, we conduct a Google Scholar search of key TL procurement terms. If a resulting paper is not in one of the above journals but demonstrates high-quality research and appropriately incorporates findings from papers sourced from the above journals, it is retained.

Fourth, we include industry reports and non-peer-reviewed white papers in our review, with very specific conditions. These reports must be transportation industry-driven or have a clear industry partnership but without showing bias toward or against a particular company. For example, marketing or promotional material is strictly excluded. These industry reports are included in our section on suggested future research to demonstrate the direction practitioners are headed. The report topics suggest opportunities for future applied research that could have a wider impact, as the target audience would extend beyond the academic community to include practitioners—from transportation and procurement managers, to executives making strategic decisions within shipping and transport firms, to name a few possibilities.

We utilize an iterative approach to process steps (3) and (4), as suggested by Webster and Watson (2002). After identifying the leading journals and relevant articles, we conduct a "backward" search by reviewing citations in the first set of papers, followed by a "forward" search identifying articles that cite the initial set of articles already identified. We use Google Scholar's search engine for the initial and iterative searches.

After this process, we retain only papers that fit within the boundaries of our review scope. We consider a time frame that spans from 1982 (just after the industry was deregulated) to October 2022. We limit our focus to TL transportation because of its size, importance, and complexity. Moreover, we exclude other transportation modes because the procurement process, contractual agreements, and interactions between buyer and supplier vary widely between the modes. By focusing on the TL context, we avoid diluting the implications and contributions of this review.

The inclusion/exclusion process described above results in a total of 106 papers spanning 38 journals. The resulting list of journals, the original lists to which they belong, and a breakdown of the number of papers from each journal are summarized in Table 1.

To summarize the resulting set of literature, we develop a concept matrix of the literature, as suggested by Webster and Watson (2002). We identify each paper resulting from the selection steps (2) through (4) and map them to the make versus buy decision, strategic versus execution

TABLE 1 Summary of journals reviewed.

Journal	List	Count
Transportation Journal	WoS, PP	14
Transportation Research Part E: Logistics and Transportation Review	WoS	12
Transportation Research Part B: Methodological	WoS	11
Transportation Research Record	WoS	11
Journal of Business Logistics	SCM, PP	6
Production and Operations Management	SCM	5
Transportation Science	WoS	5
Journal of the Operational Research Society	–	4
Interfaces	–	3
International Journal of Logistics Management	PP	3
International Journal of Physical Distribution & Logistics Management	PP	2
Logistics and Transportation Review	–	2
The American Economist	AEA	2
Transportation Research Part C: Emerging Technologies	WoS	2
American Economic Review	AEA	1
Annals of Operations Research	–	1
Artificial Intelligence	–	1
Business Horizons	–	1
Combinatorial Auctions	–	1
Computers and Operations Research	–	1
Economic Annals	–	1
EURO Journal on Transportation and Logistics	–	1
European Journal of Operational Research	–	1
International Journal of Logistics Research and Applications	–	1
International Journal of Logistics Systems and Management	–	1
International Journal of Transport Economics	–	1
Journal of Supply Chain Management, Logistics and Procurement	–	1
Journal of the Transportation Research Forum	–	1
Logistics Research	–	1
Logistik Management	–	1
Networks and Spacial Economics	–	1
Operations Research	SCM	1
Optimisation, Econometric and Financial Analysis	–	1
Production and Inventory Management Journal	–	1
The Journal of Law and Economics	–	1
The RAND Journal of Economics	–	1
Transport Reviews	–	1
Transportation Research Part A: Policy and Practice	WoS	1
Total		106

Abbreviations: AEA, American Economic Association Top 5; PP, Publication Productivity in the Supply Chain Management Discipline; SCM, SCMlist; WoS, Web of Science Transportation Topics.

timing, and perspective framework described above. Each paper's decision, timing, perspective, and theoretical basis are summarized in Table 2.

SUMMARY OF THE EXISTING LITERATURE

The Motor Carrier Act of 1980 deregulated the trucking industry. As a result, barriers to entry for carriers were considerably reduced. Carriers could now build networks to serve their customers and control how they set their prices based on internal costs and market conditions. Efficiency, price, and service level became carriers' competitive advantages. Both shippers and carriers began to put greater emphasis on how they would manage these buyer–supplier relationships.

In response to the new industry dynamics, a stream of literature developed around the evolving nature of the shipper–carrier relationship. La Londe and Cooper (1989) and Rinehart (1989) demonstrate shippers' and carriers' dependence on one another and both parties' expectations that their use of close contractual (rather than transactional) relationships would continue to increase in the coming years in terms of both volume and revenue. In addition, Phillips (1991) assesses the contractual relationships that formed. While the above studies consider both shippers' and carriers' perspectives, Crum and Allen (1990, 1991) take a somewhat different angle, exploring how the evolving shipper–carrier relationships impact carriers' business and operational performance.

In this section, we segment the remaining literature by perspective (shipper or carrier) and summarize the main themes that have been explored under each category

TABLE 2 Matrix of existing literature.

Paper	Strategic make	Strategic buy	Execution make	Execution buy	Theory Groundinga	Key findings and contributions
Shipper perspective						
Abshire and Premeaux (1991)		✓			MA	Shipper and carrier perceptions of importance of certain carrier selection criteria differ.
Acocella et al. (2020)		✓		✓	RC, SD	Market conditions and contract prices competitiveness have largest impact on carrier acceptance.
Baker (1984)		✓			MA	Post-deregulation, carriers should focus on service differentiation instead of competitive pricing.
Baker and Hubbard (2003)	✓	✓			OD	For-hire trucking companies find operational efficiencies and profit better than in-house services.
Bardi et al. (1989)		✓			MA	Shippers and carriers differ in how they weigh carrier performance criteria.
Basu et al. (2015)		✓			LR	Strategic TL procurement lit. has simplifying assumptions of demand, limited non-price focus.
Basu et al. (2017)		✓			MA	Shippers should use carbon footprint, network, and on-time delivery in carrier selection criteria.
Beier (1989)		✓			RC	Carriers learn from and improve efficiency through repeated experience at the same drop-off.
Boada-Collado et al. (2020)		✓			RC	Partial demand information can increase contract commitments and increase available capacity.
Brown and Greenlee (1995)	✓				OD	After deregulation, competition improved for-hire carrier service, reducing private fleet advantages.
Buer and Kopfer (2014)		✓			MA, AU	Offers a winner determination problem solution algorithm for lane bundles.
Burks et al. (2010)	✓	✓			OD	From 1977 to 1997 more specialized freight switched from private fleets to for-hire.
Caplice and Sheffi (2003)		✓			AU, GT	Determines best set of carriers to use and optimal assignment of carriers to each lane within network.
Caplice and Sheffi (2006)		✓			AU	Reviews the TL reverse auction process and bid construction.
Caplice (2007)		✓			AU	Reviews TL reverse auction and bid construction, in the context of electronic markets.
Caplice (2022)		✓			EM	Identifies directions in which TL transportation industry is heading.
Clouse and Gupta (1990)	✓	✓			OD	Shippers divested private fleets after deregulation; JIT required long-term core carrier partnerships.
Crum and Allen (1990)		✓			CD	EDI, long-term contracts, and smaller carrier bases have caused changes in TL service procurement.

TABLE 2 (Continued)

Paper	Strategic make	Strategic buy	Execution make	Execution buy	Theory Groundinga	Key findings and contributions
Ergun et al. (2007)				✓	AU	Shippers and carriers can collaborate to reduce deadhead by requesting continuous moves.
Farris and Pohlen (2008)	✓	✓			MA, OD	Develops a framework for a shipper to evaluate if it should continue operating its private fleet.
Figliozzi et al. (2005)		✓			AU	The amount of information disclosed impacts shippers' (carriers') consumer surplus (profit).
Fugate et al. (2009)		✓			RD, RO	Close, long-term shipper–carrier relationships can improve operational performance.
Gibson et al. (1993)		✓		✓	MA	Shippers need to carefully (re)consider the carrier performance metrics they use in procurement.
Gibson et al. (1995)		✓			MA	Shippers should use carrier certification as part of their supplier selection process.
Guastaroba et al. (2009)	✓	✓			MA	Considers shipper's strategic stage decision to vertically integrate transportation and/or outsource.
Guo et al. (2006)		✓			MA	Extends carrier assignment models to include non-price objectives and carrier transit point costs.
Hu et al. (2016)		✓			MA	Offers a winner determination problem solution algorithm that includes service level (transit time).
Johnson and Schneider (1988)	✓	✓			OD	Deregulation did not kill the private fleet as many predicted it would.
Kantari et al. (2021)		✓		✓	MA	Fill rate improves with spot sourcing but reliability and utilization worsen.
Kuyzu (2017)		✓			MA	Proposes an algorithm to solve the lane covering problem with lane bundling.
Ledyard et al. (2002)		✓			MA	Lane bundling implemented by Sears Co.; did not capture capacity limitations or non-price factors.
Lim et al. (2008)		✓			MA	Algorithm for winner determination carrier selection decision in volume guarantee contracts.
Lu (2003)		✓			MA	Shippers pay higher total direct costs but lower hidden costs when reputation is considered.
Ma et al. (2010)		✓			MA	Solution approach for winner determination problem with uncertain demand but certain capacity.
Maltz (1993)	✓	✓			TC	Long-term contracts plus private fleet can reduce costs and limit dependency, and lock-in to carriers.
Meixell and Norbis (2008)		✓			LR	Identifies gaps in transportation mode choice literature.
Mes et al. (2009)				✓	AU	Strategies (e.g., delays and breaking commitment) with spot carriers to maximize shipper revenues.

(Continues)

TABLE 2 (Continued)

Paper	Strategic make	Strategic buy	Execution make	Execution buy	Theory Groundinga	Key findings and contributions
Miller et al. (2021)		✓			SD	Shippers', carriers', and 3PLs' business costs more tied to spot market after US ELD mandate.
Mixon et al. (1994)	✓	✓			TC	Supports Smith (1993) use of transaction cost theory to explain the TL industry post-deregulation.
Moore et al. (1991)		✓			MA	Offers a winner determination problem solution, but does not allow for conditional bids.
Öner and Kuyzu (2021)		✓			MA, GT	Offers a winner determination problem solution algorithm for lane bundles.
Özener and Ergun (2008)				✓	GT	Shipper collaboration reduces empty miles, increases power to renegotiate prices.
Rajapakshe et al. (2014)	✓	✓			MA, RD	Offers algorithm for shippers to identify a sub-network of lanes best suited for dedicated fleets.
Rekik and Mellouli (2012)		✓			MA, AU	Proposes solution for reputation-based winner determination problem.
Remli and Rekik (2013)		✓			MA, AU	Solution approach for winner determination problem with uncertain demand but certain capacity.
Remli et al. (2019)		✓			MA, AU	Solution approach for winner determination problem with both uncertain demand *and* capacity.
Sandholm (2002)		✓			MA, AU	Solution approach for winner determination problem.
Scott (2015)				✓	AU	Shipper should share more information sooner: spot prices increase as tender lead time decreases.
Scott et al. (2017)		✓		✓	RC, EM	Carrier load rejections are influenced by demand uncertainty, market conditions, and volume.
Scott et al. (2020)		✓		✓	RC, TC	Implicit and explicit contracts improve carrier performance. Effect decreases in tight markets.
Sheffi (2004)		✓			AU, MA	Shippers prefer long−/mid-term contracts to avoid future price volatility, ensure capacity and quality.
Smith (1993)	✓	✓			TC	Demonstrates how transaction cost theory explains the deregulated trucking industry.
Stojanović et al. (2011)	✓	✓			TC	A combination of private fleet and for-hire services can offer value over purely outsourcing.
Tibben-Lembke and Rogers (2006)		✓		✓	RO	Demonstrates the opportunities for options contracts in TL transportation.
Xu and Huang (2013)		✓			AU	Central third-party auctioneer for uncertainty in both supply and demand; simultaneous bidding.

TABLE 2 (Continued)

Paper	Strategic make	Strategic buy	Execution make	Execution buy	Theory Groundinga	Key findings and contributions
Xu and Huang (2014)		✓			AU	Offers a solution approach for the winner determination carrier assignment problem.
Yadati et al. (2007)		✓			AU, MA	Solution approach for the winner determination problem for general logistics services.
Zhang et al. (2014)		✓			AU, MA	Solution approach for the winner determination carrier assignment problem.
Zhang et al. (2015)		✓			AU, MA	Solution approach for the winner determination problem; uncertain demand but certain capacity.
Zsidisin et al. (2007)		✓		✓	RC, RD	Close relationship with carriers offers better acceptance, on-time delivery, pre-positioned capacity.
Carrier perspective						
Brown (1984)		✓		✓	OD	Post deregulation, number of brokers exploded; they compete with and complement asset carriers.
Brown and Inaba (1996)				✓	OD	Asset carriers provide brokerage services when they have scale of network and shippers.
Brusset (2009a)				✓	RC	Choice of min. commitment, quantity flexibility, price-only contracts with unlimited capacity.
Brusset (2009b)		✓			GT	Information asymmetries of shippers' outside options benefit the shipper.
Chang (2009)		✓			AU	Bundles of spot loads may be more valuable to the carrier than each load individually.
Chen et al. (2009)		✓			AU	Bid generation problem solution that enables complete set of all possible bids to be considered.
Collignon et al. (2020)				✓	CS	Screening and interfaces with financial institutions build trust on public spot electronic markets.
Corsi and Stowers (1991)		✓			CD	Despite mkt. concentration after deregulation, operating expenses, revenues decreased 1977–1987.
Crum and Allen (1991)		✓			RC, RD	In the decade after deregulation, carriers became more dependent on main contracted shippers.
Figliozzi et al. (2003)				✓	AU	Develops framework of carriers' strategies on a central online marketplace.
Figliozzi et al. (2006)				✓	AU	Quantifies opportunity costs in sequential auctions to help carriers with spot load bids.
Figliozzi et al. (2006)				✓	AU	Proposes central, collaborative mechanism for carriers to bid on an incoming load.
Garrido (2007)				✓	AU	Double-auction scheme allocates shipments to unused capacity to reduce deadheads and costs.

(Continues)

TABLE 2 (Continued)

Paper	Strategic make	Strategic buy	Execution make	Execution buy	Theory Groundinga	Key findings and contributions
Guo et al. (2022)				✓	TC, AU	Considers heterogeneous transaction costs to match supply and demand on online platform.
Hammami et al. (2019)		✓			AU	Addresses carriers' bid generation problem with a heterogeneous fleet.
Hammami et al. (2021)		✓			AU	Addresses carriers' bid generation problem with stochastic prices.
Haughton et al. (2022)				✓	SD	Selfish behavior in the spot market degrades the efficiency of the market and leads to higher prices.
Huang et al. (2011)				✓	MA	Brokers should select carriers on load characteristics and composite not single performance metrics.
Kuyzu et al. (2015)		✓		✓	AU	Carrier bid generation problem accounting for synergies among lanes and competing carriers' bids.
Lee et al. (2007)		✓			AU	Carrier bid generation algorithm, trade-off of vehicle reposition cost vs. revenue of serving lane.
Lindsey et al. (2014)				✓	MA	Procedures for 3PL to determine ranked list of potential carriers for an incoming spot shipment.
Lindsey and Mahmassani (2017)				✓	MA	Behavior-based conceptual framework for 3PL to improve search for capacity on the spot market.
Mesa-Arango and Ukkusuri (2015)		✓			AU, MA	Develops algorithm for carriers' bid generation pricing problem for lane bundles.
Mikl et al. (2020)		✓		✓	OD, CD	Digital freight forwarders may disrupt the industry.
Muckell et al. (2009)				✓	SD	Algorithm for how freight brokerages can offer carriers smart backhaul and load-sharing services.
Othmane et al. (2019)		✓			AU	Heuristic for carrier that already has contracted lanes with shipper to construct combinatorial bids.
Rakowski et al. (1993)		✓			OD, DC	Evidence that after deregulation, the many carriers continuing to operate were financially stable.
Song and Regan (2001)				✓	OD	3PLs have been joined by new entrants; industry will further expand and transition before settling.
Song and Regan (2003)		✓			AU	Combinatorial auction process benefits carriers as well as shippers (latter previously well studied).
Song and Regan (2005)		✓			AU	Develops an approximation method for carriers to solve their bid generation problem.
Stephenson and Stank (1994)		✓			OD, RD	Comprehensive framework of strategies carrier executives identify as critical to future profitability.

TABLE 2 (Continued)

Paper	Strategic make	Strategic buy	Execution make	Execution buy	Theory Groundinga	Key findings and contributions
Triki et al. (2014)		✓			AU	Probabilistic optimization model combining carrier bid generation, pricing, and routing problems.
Wang and Xia (2005)		✓			AU	Develops algorithm for carriers' bid generation pricing problem for lane bundles.
Yoon et al. (2016)		✓			RD	Capacity-based risk mitigation strategies for 3PLs with demand uncertainty and guaranteed capacity.
Zhou and Wan (2022)				✓	CD, EM	Digital freight matching firms' entrance did not reduce traditional freight forwarders' profitability.
Both shipper and carrier perspectives						
Hubbard (2001)		✓		✓	TC, RC	Increasing market thickness increases likelihood that simple spot arrangements govern transactions.
Lafkihi et al. (2019)		✓		✓	LR	Review of e-commerce transportation procurement literature across all transport modes.
Lindsey and Mahmassani (2015)				✓	MA	Detailed information of compensation a carrier requires would improve shippers' spot capacity sourcing.
Murphy et al. (1997)		✓			MA	Shippers' and carriers' perceptions of importance of carrier selection criteria are very similar.
Phillips (1991)		✓			RC, TC	The contractual relationships that formed after deregulation were economically efficient.
Premeaux (2002)		✓			MA	Follow-up to Abshire and Premeaux (1991); similar findings to the study done 10 years earlier.
Rinehart (1989)		✓			RD	Shippers are more operationally dependent on the carriers than vice versa; perceptions are incorrect.
Scott (2018)				✓	AU	Low frequency and volume, high demand volatility and revenue decrease load acceptance rate.
Scott (2019)		✓		✓	OD, AU	Carriers with existing business bid more frequently, substitute contract price for spot bids.
Tjokroamidjojo et al. (2006)				✓	AU	More advanced load information helps improve carriers' operational efficiency and service.
Tsai et al. (2011)		✓		✓	RO	Demonstrates optimal options contract design for TL transportation.

Abbreviations: AU, Auction Theory; CD, Competitive Dynamics Theory; CS, Cue Signaling Theory; DC, Dynamic Capabilities Theory; EM, Empirical Analysis; GT, Game Theory; LR, Literature Review; MA, Multi-Attribute Value Theory; OD, Organizational Design; RD, Relational Contract Theory; RD, Resource Dependency Theory; RO, Real Options Theory; SD, Supply and Demand Theory; TC, Transaction Cost Theory.

described in Figure 1—that is, the decision (make vs. buy) and the timing or stage (strategic vs execution).

Shipper perspective

In this section, we describe the research that takes the shipper's perspective, for each of the decision and timing combinations. We find that within this set of literature, the strategic buy decision is considered far more frequently than the other quadrants of the decision-stage framework in Figure 1.

Strategic make

The use of private or dedicated fleets—that is, the decision by a shipper to "make" or vertically integrate the TL transportation service—is an important piece of the overall transportation system. In fact, it accounted for 50% of the $830 billion trucking industry in the United States in 2021 (Council of Supply Chain Management Professionals, 2022).

Despite its importance, there is very limited research guiding a shipper's strategic decision to provide the TL service in-house. Instead, much of the literature focuses on the strategic choice of transportation mode (over-the-road, rail, air, or water) or on decisions about for-hire carrier selection (i.e., the "buy" decision). The strategic make decision for shippers focuses on where to use existing private fleets or when to establish a new in-house fleet. Much of the existing literature implicitly takes an organizational design theory approach to describe the efficiencies gained by using private and dedicated fleets.

The choice to use a new or existing private or dedicated fleet requires the shipper to consider trade-offs between the level of service (e.g., on-time pickup and delivery, low damage risk) offered by in-house service and the reduced cost and improved efficiency and utilization that may be achieved by outsourcing (Farris & Pohlen, 2008; Morse, 1987).

These trade-off decisions have been considered extensively in the purchasing and operations management literature, but to a much lesser extent in the TL transportation context. One such study, for example, finds that after deregulation, the service-level advantages of using private fleets decreased because for-hire carriers' service levels were now a competitive advantage (Brown & Greenlee, 1995). While these findings compare behaviors soon after deregulation, and thus reflect a certain point in the trucking industry's evolution, they suggest that the trade-offs that must be considered when using in-house TL services are not straightforward.

As deregulation loomed, experts claimed that the likely increase in competition would make private fleets inefficient and obsolete (Johnson & Schneider, 1988). In fact, Burks et al. (2010) study industry data from 1977 to 1997 representing trends in private and for-hire fleets and find that during this time period, there was indeed an increase in the use of for-hire carriers for long-haul moves. But during that same time period, there was an increase in private carriage for local operations, presumably because short-haul operations lend themselves better to efficient, tour-based networks. Similarly, Clouse and Gupta (1990) note the need for reliable, for-hire carrier services as shippers moved away from private carriage and toward Lean manufacturing and Just-in-Time processes in the aftermath of the Motor Carrier Act.

However, according to Johnson and Schneider (1988), deregulation did not kill the private fleet as many predicted it would. Instead, it required shippers to think more deliberately about where and when to use private/dedicated capacity options. For example, viewing the topic through a transaction-cost lens, Smith (1993) describes how long-term contracting became an efficient choice post deregulation, but asserts that vertical integration would be more suitable when there is high transaction uncertainty. This view was supported with empirical evidence in a follow-on piece (Mixon et al., 1994).

A few papers offer insights into which conditions indicate that shippers should plan to serve demand with their own existing fleets, and which suggest that they should establish contracts. For example, Maltz (1993) adopts a transaction-cost lens and finds that the shipper should choose to utilize its private fleet where relationship-specific investments by the carrier may be necessary and the shipper wants to reduce its dependence on that carrier. In a related study, Baker and Hubbard (2003) show that for demand that requires complex services, the shipper is better off vertically integrating, whereas for standard or simple business, for-hire trucking companies are better suited to finding efficiencies and thus increasing profits. Finally, Rajapakshe et al. (2014), building from resource dependency theory and multi-attribute value theory, suggest that shippers should take empty backhauls and lane-sharing into consideration when deciding which lanes to cover with dedicated capacity.

The complexity of this make or buy decision is demonstrated in several papers. Guastaroba et al. (2009) use multi-attribute value theory to assign lanes to either a private fleet or for-hire carriers. The authors demonstrate that in a reasonable amount of time, an exact solution can be found for a very simplified scenario of a single load per lane and the shipper's fleet capacitated at one truck. Taking a transaction-cost perspective, Stojanović et al. (2011) add that a more realistic formulation of the make or buy

decision should consider demand variability in individual lanes. Min (1998) develops a decision-support system that assists shippers with determining which lanes to include in a private fleet by using an analytic hierarchy process.

A similar theme appears in an industry-sponsored report by Mulqueen (2006), where fleet size is determined by calculating the most reliable or repeatable volume levels on lanes that complement each other. In a study partnered with Walmart, Caplice et al. (2011) develop a stochastic optimization approach to identify which lanes in a distribution network should be covered by the private fleet and which should be offered to for-hire carriers as part of an annual procurement event. Again, the variability of the volume on the different lanes was the dominant factor in the decision. Another industry-led report, Tsu and Agarwal (2009), utilizes this approach to illustrate how private fleets can be expanded by incorporating relays, where the trailer moves continuously but drivers are swapped in and out.

In practice, the decision of whether to introduce a private or dedicated fleet is both cost-based (where the vertically integrated solution has very high efficiency) and capacity-based (where the shipper is unable to secure for-hire trucking assets consistently and/or at an acceptable price). Simulation and optimization methods are often used, and Panchalavarapu (2010) outlines a typical approach commonly applied in practice. Interestingly, the annual spend on private or dedicated fleets increased by 39% in 2021, during the Covid-19 pandemic, as shippers scrambled to secure truck capacity (Council of Supply Chain Management Professionals, 2022).

Execution make

The execution stage decisions occur when a load needs to be moved. For shippers, the make decision here is whether to manage loads internally or with outsourced carriers. This decision often relates to capacity balance at the time. If a truck is not available from the private fleet, it may be faster and/or more economical to outsource than to reposition an empty truck.

In practice, this is a feature within more sophisticated transportation management systems (TMS). Traditionally, a TMS mainly handled shippers' execution of purchased transportation services, both spot and contract. TL carriers, on the other hand, use fleet management systems (FMS) to manage the operation of their assets, including monitoring, dispatching, routing, and driver assignment. The challenge for shippers that use both for-hire and private fleet assets is to determine, in real time which type of asset is best suited for a particular shipment. Selection criteria for for-hire assets are different from those for a dedicated or owned asset, because for-hire movements are "one-way" while the private and dedicated assets typically are "tour based," meaning there must be a backhaul movement to reposition the trucks where they need to be for the next load. This is a challenging problem that little existing research has explored.

In our review of the literature, we do not find any peer-reviewed papers that take the shipper's perspective on whether to use in-house or for-hire TL transportation services at the execution stage. In this setting, the shipper has a load it needs moved and is deciding which service to use for that specific transaction, rather than determining whether future demand should be served with a private fleet or with outsourced capacity. However, one company-partnered report, Lee and Po (2007), studies this problem for a fruit importer. The authors develop a decision framework to determine which inbound containers should be delivered with the company's private fleet and which by contracted carriers as loads come into port.

Strategic buy

The vast majority of the transportation procurement literature from the shipper perspective relates to the strategic buy decision. The process is described in Caplice (1996), Caplice & Sheffi, 2006, and Caplice (2007), particularly in the context of electronic markets. There is no single "market price" for each lane because carriers' network structures, internal costs and services, and customer base all differ. This is demonstrated in Beilock et al. (1986). Shippers use reverse auctions to determine a reasonable price for their business, to select suppliers, and to establish contracts (Caplice & Sheffi, 2006; Caplice, 2007). Sheffi (2004) notes that in most cases, shippers seek long- and mid-term contracts for TL services to lock in prices, avoid market volatility, and ensure quality of service. Much of the relevant literature builds off of game theory, auction theory, multi-attribute value theory, transaction cost theory, relational contracting, real options theory, and organizational design theory to develop analytical models and algorithms to support the auction decision. The literature on the strategic buy decision typically focuses on the carrier assignment problem, where a shipper selects which carrier(s) to hire for which lanes or bundles of lanes.

A large number of papers develop sophisticated combinatorial and other optimization models to solve the carrier assignment problem (Buer & Pankratz, 2010; Buer & Kopfer, 2014; Caplice, 1996; Caplice & Sheffi, 2003; Chen et al., 2009; Guo et al., 2006; Kuyzu, 2017; Lim et al., 2008; Sandholm, 2002; Sandholm et al., 2005; Yadati et al., 2007). These models allow for three major

enhancements to the procurement decision. First, they allow carriers to submit sets or groups of lanes as bundles or packages that are assigned as an all-or-nothing condition in the optimization model. Second, they allow shippers to specify preferred constraints or conditions, such as "Ensure carrier x is awarded at least y volume" or "Only include z carriers in the final assignment." This approach lets shippers design a solution that considers more than just the cost. Third, they allow shippers to favor or disfavor non-financial aspects in the selection process by modifying coefficients in the objective function, such as "Reduce the bids from incumbent carriers by 5%." Collectively, these papers focus on developing a better or more expressive language for shippers and carriers to bid and assign lanes within an auction.

Often, authors taking a modeling approach must simplify the problem to obtain tractable solutions. As a result, they fail to account for real-life complexities such as service levels. For example, Ledyard et al. (2002) describe a combined-value auction, where the carrier can combine and bid on a set of lanes that creates more value than the sum of the individual lanes. In the strategic bid process, this is also referred to as a package bid. The authors aim to capture the carriers' preferences for leveraging their economies of scope and resulting ability to handle a set of lanes at a lower cost, rather than multiple carriers bidding on and handling the lanes separately. While the study allows for package bids, it must simplify other factors to obtain a solution. For example, it does not consider carriers' capacity limitations or their non-price performance factors in the shipper's carrier selection decision. Also, the authors model demand as deterministic and assume complete adherence to the generated routing guide (a list of contracted and backup carriers). This, of course, is not the case in reality.

An earlier work by Moore et al. (1991) applies a mixed integer programming (MIP) model to solve the carrier assignment problem for Reynolds Metals. The model includes an option for the carrier to submit conditional bids. However, even without that option, the model was not implemented due to computational limitations at the time, demonstrating the challenges created by the size and complexity of these problems.

In traditional supplier selection processes, particularly in commodities markets or for simple products, the supplier with the lowest bid price wins the business. This is not the case in TL transportation services, however. A small set of studies explicitly consider non-cost factors such as carrier reputation (Lu (2003) and Rekik and Mellouli (2012)), carrier certification status (Gibson et al., 1995), on-time delivery expectations (Basu et al., 2017), and transit time (Hu et al., 2016) in the carrier selection decisions. Carriers' service level and incumbency are discussed by Beier (1989); Gibson et al. (1993) and Guo et al. (2006). Further, Abshire and Premeaux (1991), Bardi et al. (1989), and Murphy et al. (1997) consider how shippers and carriers perceive the importance of different carrier performance metrics in the carrier assignment problem. Finally, Turner et al. (2012) demonstrate that shippers should incorporate diesel price uncertainty, through fuel surcharges, into the carrier assignment decision, specifically when working with 3PL providers.

Nevertheless, the majority of TL procurement studies are limited in their applicability to actual practice. For example, previous work assumes deterministic and known demand. Few researchers have considered uncertainty in lane volume by using two-stage stochastic integer programming (Ma et al., 2010), two-stage robust optimization Remli and Rekik (2013) and Zhang et al. (2015), or a sampling-based, two-stage stochastic programming approach (Zhang et al., 2014). Moreover, Boada-Collado et al. (2020) find that demand uncertainty can impact the optimal contract term length.

Where demand uncertainty is considered, complete load acceptance by the carrier is often assumed, thus disregarding carriers' decisions in the execution stage. There is no consideration of carrier service failures and the resulting costs in these more sophisticated approaches. Much of the literature applies general purchasing strategies, such as reducing the supplier base, prioritizing carriers' experience level, certification programs, and guaranteed-volume agreements, to transportation applications, which oversimplifies the realities of supplying transportation. In addition, it often focuses on a macro-level decision by the shipper regarding which carrier(s) from a set to source from across its business. In reality, the carrier selection decision is done at a micro, lane level; level of service and expected performance factor into the shipper's trade-off between cost and service for each lane after carriers have submitted bid prices, as discussed in Caplice and Sheffi (2003).

We do find one study that explicitly considers uncertainty in both demand volumes and the availability of carrier capacity: Remli et al. (2019) use robust optimization methods to solve such a winner determination problem. This paper is among the very few to realistically consider the execution stage uncertainty in both supply and demand in the strategic procurement stage's decisions. Moreover, two studies, Xu and Huang (2013) and Xu and Huang (2014), suggest a framework in which a centralized market clearing broker establishes TL contracts. This process would allow for uncertainty in both demand and capacity to be considered. However, the authors' suggested framework does not currently exist for the contract procurement process.

Some research has considered what a shipper can do during the strategic phase to improve carrier service later

on, during execution. For example, Figliozzi et al. (2005) consider how much information should be shared by the shipper during the strategic auction to balance transportation costs with service level (e.g., in the form of freight acceptance). Acocella et al. (2020) demonstrate that shippers can expect better acceptance of contracted loads if they keep contract prices competitive with current market conditions. This can be achieved with more frequent bidding or dynamic contract pricing (Acocella et al., 2022a).

This relationship between contract and spot market price is explicitly noted by Miller et al. (2021), who conclude that shippers should expect their contract costs to be more closely tied to spot market prices following the mandated implementation of electronic logging devices (ELDs) that led to stricter monitoring of drivers' adherence to hours-of-service regulations.

Another strategic phase decision that can impact execution phase outcomes, explored by Scott et al. (2020), is the degree to which the contract is explicit. The authors suggest more explicit contracts (where volume and other aspects of the contract are specifically defined) to help improve carrier performance.

These two papers also consider the impact of macroeconomic market conditions on shippers' and carriers' behaviors and, separately, on asset-based carriers as compared to non-asset-based 3PLs. Finally, while limited to theoretical modeling, Fugate et al. (2009) suggest collaborative actions shippers can take to develop long-term strategic relationships with carriers for improved performance at the operational level.

Baker (1984) argues that while there has been research on how shippers make carrier selection decisions, there has been very little that considers how shippers decide to eliminate carriers from their supply base. The author demonstrates how shippers eliminate carriers and suggests marketing efforts carriers can use to avoid losing the business. However, in a much later paper, Guo et al. (2006) discuss carrier base reduction as an outcome of the procurement process.

Few studies (Öner & Kuyzu, 2021) have explored collaboration among shippers. Some have focused on improving system-wide efficiencies through collaboration to reduce deadheads, or empty miles driven (Ergun et al., 2007; Kuyzu, 2017; Özener & Ergun, 2008).

In practice, optimization-based models are widely used to procure TL transportation as part of an annual strategic procurement process. While they are a source of many complaints in practice (Caplice, 2022; Cassidy, 2021; Coker, 2022; Zweier, 2021), annual procurement events do not appear to be going away, as they do provide some level of certainty in pricing and carrier assignment. As such, they are an area for further academic research with the potential for high practical impact. Additionally, there is a lack of empirical research on the actual use and effectiveness of the more complex bidding approaches described in these papers, such as expressive, combinatorial, or package bids.

Execution buy

The implicit assumption in essentially all of the strategic buy literature is that transportation procurement is a single-stage process, and that the tendering of the actual shipments occurs without problems or deviations from the plan. In reality, the resulting carrier assignment from the strategic stage auctions is a set of contracts that are binding in price, but not in the volume of freight tendered by the shipper, nor in the capacity provided by the carrier. Therefore, uncertainty exists in that second (execution) stage of transportation procurement. Only a few of the many studies on transportation procurement consider the effect of the execution buy stage and how it should be considered in strategic procurement decisions. The existing literature often builds from multi-attribute value theory, auction theory, and transaction cost theory.

When a load must be moved, under the "buy" decision, the shipper can still choose to offer the load to a contracted carrier, if one exists for the lane in question, or to put the single load out to bid on the spot market. If the load is tendered to the contracted carrier, it may be rejected by that carrier, and the shipper may end up resorting to the spot market after exhausting any backup carriers it may have in place. The additional cost of these rejections has been estimated to be in excess of 10% to over 30%, depending on the state of the market, as demonstrated by industry-led reports such as Kim (2013), Aemireddy and Yuan (2019), and Garza and Shekhar (2022). Either of these scenarios—where the shipper chooses to use the contract or spot capacity, or where the shipper is forced to use the spot market—falls into the execution buy quadrant.

The first scenario described above is often studied in the context of factors that contribute to contracted carriers' decisions to accept or reject loads. This helps shippers to identify how to reduce load rejections and exposure to the spot market. Such factors include operational effects like demand variability, economic conditions such as supply and demand imbalances, and relationship factors such as the amount of volume transacted between the parties, as studied in Scott et al. (2017) and Acocella et al. (2020). These studies, which build off relational contract theory, consider the execution stage performance of TL contracts and how that should impact shippers' strategic decisions.

Research has demonstrated that carrier service at the execution stage is better when there are more explicit, rather

than implicit, contracts (Scott et al., 2020) and when there is a close partnership rather than a transactional relationship (Zsidisin et al., 2007). In a similar vein, utilizing a transaction cost theory perspective Hubbard (2001) finds that shippers and carriers form contracts less often when the market is thick (that is, when there are more buyers and sellers in the market) and instead rely on spot transactions due to the competitiveness of that market environment.

While generally overlooked in the literature, the second scenario (where the shipper decides to utilize on-demand, spot market sourcing) has developed significantly in practice. However, the decision by the shipper to either execute a standing contract or to utilize a transactional, spot market option at the load tendering stage has received attention from only a few researchers (Kantari et al., 2021).

This stream of literature often utilizes auction theory to explore carriers' decisions regarding spot market loads. Given that carriers are profit maximizers, Mes et al. (2009) suggest strategies such as delaying commitments and allowing carriers to break commitments with penalty to help shippers choose carriers to cover their spot transactions. Scott (2018) uses auction theory to help shippers understand whether and how carriers will bid on their spot loads given specified carrier, market, and demand characteristics. The author also demonstrates the added value of an online 3PL linking shippers directly with a large pool of small, asset-based carriers. Similarly, Scott (2019) studies decisions regarding spot loads by carriers that already have concurrent contractual relationships with the shipper. The study demonstrates that shippers can expect carriers with which they have existing contract business to bid more frequently, and to substitute the contract price (if one exists for that business) for the spot bid price, especially if the contract price is kept up to date with the current market.

Another set of papers considers information sharing between shipper and carrier to improve spot interactions. Lindsey and Mahmassani (2015) find that a shipper's efforts to utilize spot capacity could be improved with better information regarding the actual price the carrier requires to serve a load. Further, when shippers provide advanced load information to the carrier, it reduces load prices (Scott, 2015) and improves carrier efficiency and service (Tjokroamidjojo et al., 2006).

Carrier perspective

After the deregulation of the trucking industry, carriers became concerned with how to operate efficiently in a newly competitive market. Corsi and Stowers (1991) study the impacts of deregulation on carriers' operations and profits and discuss keys to carrier survival in the new environment, while Stephenson and Stank (1994) identify ways carriers can increase profitability based on learning from the preceding three years.

In the TL procurement context, carriers' make and buy decisions are the inverse of those for the shipper. The make decision is in response to the shipper's need for dedicated capacity, should the carrier choose to allocate a segment of its fleet completely to that shipper. The buy decision is really a "sell" decision (which we will continue to refer to as the carrier's "buy" decision for consistency of terms). Here, the carrier's decision is whether to enter into strategic relationships through contracts with shippers and offer its capacity to contracted load tenders or to sell its services to shippers on demand on the spot market—or do both. Another decision that falls under the carrier's buy decision is whether to offer load matching or brokerage services—either in addition to its asset-based business or purely as a non-asset provider. We summarize the remainder of the literature from the carrier's perspective that falls into these categories below.

Strategic and execution make

In our framework, the carrier's make decision concerns whether to offer dedicated services to shippers. This decision involves determining whether the carrier should commit a set amount of its fleet capacity to a specific shipper. These dedicated agreements typically last multiple years, which is longer than traditional contractual for-hire agreements. While this is a substantial piece of the transportation industry, at about $415 billion in 2021 (Council of Supply Chain Management Professionals, 2022), it has only received attention in the literature from the shipper's perspective. In our systematic review, we found no articles that considered the trade-offs and opportunity costs faced by the carrier in either phase of procurement (strategic or execution). This is a clear gap in the literature that is ripe for attention.

Strategic buy

Most of the strategic buy literature from the carrier's perspective focuses on the bid construction or bid generation problem, where the carrier must decide at what price it should bid for each lane during the strategic auction. This work typically draws from auction theory, multi-attribute value theory, relational contract theory, and organizational design theory.

These studies focus on different combinations of carrier constraints and preferences, which call for more advanced algorithmic solutions (Chang, 2009; Hammami et al., 2019, 2021; Lee et al., 2007; Song & Regan, 2003,

2005; Triki et al., 2014; Wang & Xia, 2005). Other research has offered such algorithmic solutions as well. For example, Kuyzu et al. (2015) develop a stochastic bid price optimization model to enable carriers to participate in multiple auctions at the same time. In addition, Mesa-Arango and Ukkusuri (2015) consider how carriers should bid on bundles of lanes offered, and Othmane et al. (2019) build a pricing heuristic for combinatorial bid construction for a carrier that is bidding on new lanes in a new auction but already has some contracted lanes within its network. All of these studies utilize auction theory arguments.

In some cases, research that considers the strategic buy decision for the carrier takes both the carrier and the shipper perspectives. This includes Abshire and Premeaux (1991), Bardi et al. (1989), Murphy et al. (1997), and Premeaux (2002), which apply multi-attribute value theory to study differences in shipper and carrier perceptions of the importance of performance. Another set of work demonstrates the optimal form or design of a contract between shipper and carrier in which both parties agree to the terms. For example, Brusset (2009a, 2009b) consider a set of contract forms, and Tibben-Lembke and Rogers (2006) and Tsai et al. (2011) consider options contracts. However, as with the limitations to shippers' strategic procurement decisions, much of this analytical literature requires simplifying assumptions in a way that often reduces the problem to one that no longer represents real choices or solutions faced in practice.

Execution buy

The main focus of the existing literature on carriers' execution buy decision has been pricing for spot capacity. For example, Powell et al. (1988) develop a model for carriers to evaluate and price on-demand loads that have been tendered. Figliozzi et al. (2006) consider how a carrier bidding on spot loads should consider its opportunity costs for serving that load in the pricing decision. Chang (2009) introduces the synergistic minimum cost flow problem by considering that bundles of spot loads may be more valuable to the carrier than each load individually. Moreover, Lindsey et al. (2014) consider how non-asset 3PLs should price for spot market transactions to maximize profits and improve the likelihood that the asset-based carriers they call upon will accept loads. Garrido (2007) and Kuyzu et al. (2015) address the problem where a carrier must price the capacity it offers on the spot market to reposition its assets to serve its contracted business. In a related setting, Scott (2018) and Scott (2019) consider the scenario in which the carrier is bidding on a spot load from a shipper with which it has concurrent, contractual business.

A few studies related to carrier behaviors consider the design of the spot marketplace. For example, studies have demonstrated support for centralized market mechanisms (Figliozzi, 2006; Figliozzi et al., 2003; Haughton et al., 2022), cue signaling to instill trust between parties (Collignon et al., 2020), and matching to optimize for backhauls (Muckell et al., 2009) to eliminate inefficiencies.

The carrier's strategic and execution buy decision also includes whether to offer brokerage services, either by solely providing 3PL or matching services, or in addition to asset-based capacity (Brown, 1984; Brown & Inaba, 1996). A subset of the literature considers this decision and typically takes the perspective of organizational design theory. The 3PL option comes into play in both the strategic and execution stages.

Shippers' use of 3PL services has evolved since deregulation. The 1980s saw a rapid growth in both asset-based providers and non-asset brokerage services. Leading up to the Motor Carrier Act, there were approximately 70 licensed freight brokers in 1975; by 1983, that number had grown to 900 (Brown, 1984). As of 2020, there were over 17,600 brokers registered with the Federal Motor Carrier Safety Administration (FMCSA; Federal Motor Carrier Safety Administration, 2021). This massive increase created the opportunity for freight brokers to first, help coordinate the thousands of new asset-based carrier entrants, which now had virtually no barriers to entry, and second, offer matching services at the single-transaction level for shippers (Rakowski et al., 1993). As the industry further evolved, the shipping community began utilizing 3PLs as strategic suppliers (Yoon et al., 2016) rather than as backup options. In this way, the 3PL interacts with the shipper through a contract (strategic buy), and with the asset-based carrier in real time as loads materialize (execution buy), by matching the realized demand to current capacity.

A set of research directed at the 3PL community has emerged in recent years. For example, industry reports such as Freight Waves (2019a) discuss how a 3PL can ensure that it has the right mix of carrier suppliers for a set of loads. Some of the academic literature has also taken on the 3PL's perspective. For example, Huang et al. (2011) study how to improve the quality of strategic interactions to increase profitability, and Yoon et al. (2016) demonstrate under which conditions 3PLs should implement different risk-mitigation strategies to ensure that they can offer guaranteed capacity to their shipper customers. Further, Lindsey et al. (2013) explore how to utilize information about carriers' reservation prices and the attractiveness of spot loads to increase their likelihood of acceptance. Carriers' reservation price functions for spot prices are formulated by Lindsey and Mahmassani (2015) and Lindsey and Mahmassani (2017).

TABLE 3 Future research streams and suggested questions.

Research area	Research questions
Purchasing approach	
Handling uncertainty in strategic procurement	• How should uncertainty (in demand, supply, commitment, etc.) be incorporated into strategic procurement decisions? • Which sources of uncertainty have the greatest impact on procurement outcome performance, and how can they be mitigated? • How could considering current and expected future market conditions improve procurement outcome performance?
Strategic bid timing	• How does bid timing impact outcome performance? • Which network segments are suited for more/less frequent bids? • At what performance failure level should shippers enact a mini-bid? • How does the size/timing of a bid impact carrier bidding behavior? • When does the expected performance improvement outweigh the additional setup costs of more frequent bidding?
Contract design	• What forms of contract design are best used for truckload transportation, and under what conditions? • What is the optimal contract portfolio to effectively cover shippers' transportation service needs?
Performance management	
Impact of execution outcomes on strategic decisions	• How does a carrier's previous service-level performance impact a shipper's future strategic procurement decisions? • How can a shipper implement dynamic/spot pricing into its strategic procurement process, and what are the implications? • How do shipper performance metrics (e.g., demand uncertainty, rushed loads, and dwell times) impact carriers' strategic decisions? • How can considering carriers' past performance help shippers reduce the scale and complexity of the strategic bidding process?
Digitization of transportation procurement	• How are digital matching services/platforms impacting truckload procurement processes? • How are new "digital" entrants impacting the freight and logistics industry? What will be their long-term impact? • How should firms incorporate digital services (offered by either traditional 3PLs or new entrants) into their portfolio of partners?
Governance	
Shippers' vertical integration (make) decision	• What factors should shippers consider when determining whether, where, and what size fleet to institute across their networks? • How should a shipper integrate the execution of a private fleet alongside for-hire contracts?
Carriers' make decision	• What market, customer, or demand factors should an asset carrier consider when deciding whether to commit to dedicated services?

There has been a dramatic increase in attention to the freight brokerage industry in recent years due to the emergence of "digital" freight matching services (Song & Regan, 2001). Both incumbent 3PLs and new entrants are offering more automated processes. An industry report by Frost & Sullivan claims that "Digitizing the freight brokerage process has the greatest impact on improving freight efficiency, reducing empty miles and emissions as well as lowering the cost of trucking" (Frost & Sullivan, 2018). Given the potential magnitude of those benefits, it is not surprising that the literature has begun to explore the impact of digital freight matching on the transportation industry. Mikl et al. (2020) demonstrate that digital and traditional brokers' business models differ and conclude that new digital entrants indeed have the potential to disrupt the industry. Moreover, large incumbent 3PLs that have already implemented digital services are less likely to be disrupted.

Zhou and Wan (2022) empirically study the influence of digital freight startups' entry on the profitability and stock performance of incumbent 3PLs and carriers. The authors find that the entrance of digital freight matching firms has not negatively impacted profitability of incumbent 3PLs, but it has positively impacted that of large asset-based carriers.

Some research has also explored the question of how these digital matching services may achieve greater total welfare in the market. For example, Guo et al. (2022) discuss how digital freight matching platforms can elicit

information from shippers and carriers and efficiently match supply and demand.

OPPORTUNITIES FOR FUTURE RESEARCH

Our summary of the existing literature on TL procurement comes from a range of disciplines and associated theories, including law and economics (e.g., transaction cost theory, auction theory, game theory, contract theory), supply chain planning (e.g. sourcing and procurement, supplier selection, buyer–supplier relationships), business (e.g., organizational design, dynamic capabilities theory), and transportation planning (e.g., pricing and supply, demand theory).

While the variety of disciplines from which the research has emerged has likely contributed to the disconnected nature of the body of academic literature, the varying perspectives also demonstrate the applicability of TL transportation procurement to many fields and the wide-ranging potential contributions new research can have. Future researchers should build on the above-mentioned theories and others to explore additional areas of research in TL transportation procurement. Accordingly, we suggest paths for future research that would contribute to practice as well as expand on and fill gaps in the existing body of literature. By addressing those gaps, researchers can work to bring together the currently independent themes.

The real problems faced by shippers, carriers, and brokers are immensely challenging and theoretically interesting. They involve business behavior, decision making under uncertainty, resilience and risk management, and a wide range of other topics. However, research into transportation procurement tends to lag what is happening in practice. If research can catch up to actual conditions, this will lead to more practical contributions that can be implemented in a timely way. In this section, we emphasize topics that the industry has identified as current interests and challenges. We highlight industry-led studies that are either reported by companies or have clear partnerships with industry. This set of reports includes both practitioner-generated and academic white papers, as well as quality master's theses and PhD dissertations that explore relevant questions. In addition, some papers included here may not draw heavily from theory or be peer-reviewed. However, all of the studies offer opportunities for researchers to make both academic and practical contributions.

We map our proposed future research areas to the broader procurement literature domains identified by Heinis et al. (2022). In Table 3, we list these research streams and suggest a set of research questions.

Handling uncertainty in strategic procurement

The sophisticated models used for shippers' strategic buy decisions have advanced optimization methodology but not the actual procurement decisions. The uncertainty inherent in the daily execution of transportation is often assumed away in the interest of simplification to obtain tractable solutions. In practice, even if a shipper does not plan for uncertainty, it still occurs, of course. The primary problem with sophisticated optimization approaches is that to be tractable, they are static and deterministic—or make just minor nods to variability in demand. As a result, they can be very brittle in execution.

Research on how to incorporate uncertainty, such as by strategically using the spot market or dynamic pricing, could have a significant positive impact on procurement outcomes (Acocella, 2021). The sophisticated optimization techniques assume that contracts are the only solution and that the spot market is only a method of last resort when the routing guide fails. This ignores the effect that having so many—perhaps unnecessary—lanes in the annual strategic procurement process has on the effort required by both shipper and carrier. Further, cyclical market conditions have major impacts on transportation operations. Thus, it is important for shippers and carriers to first identify which sources of uncertainty may have the greatest negative impact on procurement outcomes and, subsequently, how they can best utilize this information to improve their procurement processes and outcomes.

Moreover, exploring the possibility of enforcing more binding contract commitments, such as by removing the "right to refuse" from contracts and requiring 100% acceptance (Convoy, 2020a), could help make the case for expanding the set of shipper–carrier contract forms.

Some initial work has been conducted on segmentation of freight lanes to identify those that are not amenable to generic TL contracts. For example, low-volume lanes with infrequent cadence tend not to repeat in the following year (Acocella et al., 2022b), so including them in the annual strategic procurement process might be counterproductive. Additionally, Vos (1999) suggests that TL procurement strategies should account for uncertainty related to demand surges. More work needs to be done on how to better segment lanes and determine how best to procure and manage them.

Strategic bid timing

The effectiveness of the traditional strategic bid event has received a great deal of attention from industry in recent years. Industry experts have suggested that there is still a time and

a place for the annual bid event described by the shipper's strategic buy decision. Increasingly, however, shippers and carriers are looking for alternative approaches when the execution of the contract does not go according to plan. One option that is being explored in practice is "mini-bids"—also called continuous procurement—in which shippers identify underperforming lanes with frequent load rejections and exposure to the volatile spot market. The shipper opts to put this specific business back out to auction to establish a new contract rate with a new (or potentially the same) carrier. In this way, the shipper can reduce exposure to the spot market, stabilize prices, and ensure that a carrier in which it has confidence serves the business (Cassidy, 2021; Bandaru & Dolci, 2020; Zweier, 2021).

Researchers should consider addressing questions such as how the timing and frequency of procurement bids may impact performance outcome. Additionally, it may be beneficial for shippers to procure some business segments (i.e., lanes) through the traditional annual strategic bid, and procure others more frequently through mini-bids. How to define these segments, the expected resulting benefits, at what point (performance failure-level threshold, for example), and the frequency at which shippers should enact a mini-bid are all topics that should be explored further. These are both important questions for practitioners and subjects where the research community could offer valuable insights.

Contract design

While a few studies have considered alternative freight contract designs to the long-term, fixed-price contract typically used today, the research is very limited and has some drawbacks. First, the contract forms described in the existing literature do not truly represent the contracts being used or considered by transportation practitioners. Second, the modeling approaches used require oversimplifications of the nuances of the TL market, resulting in insights with limited applicability. However, industry-led and -partnered reports do point to opportunities for new or alternative contract designs of interest to practitioners, such as index-based contracts (Acocella et al., 2022a, 2022b; Bignell, 2013; Caplice, 2022; Driegert, 2003; Sinha & Thykandi, 2019; Schneider, 2019; Sokoloff & Zhang, 2020).

In practice, some shippers have implemented tiered volume contracts; for example, when surge volume (loads tendered to the contracted carrier over the expected volume) is priced at a higher rate to incentivize carrier acceptance. Other types of contracts that have been implemented to a limited extent include guaranteed capacity and guaranteed volumes. These are few and far between, and thus, there is a huge opportunity here to create new theoretical and practical contributions.

The practicing community could benefit from further exploration by researchers of the actual contractual forms considered by industry. This research could include how to design various types of contracts and the conditions under which they should be implemented—for example, on which segments of a shipper's network, with which types of carriers, and for which types of shippers.

Impact of execution outcomes on strategic decisions

Much of the existing literature considers either the strategic or the execution stage of the shipper's buy decision independently. However, it is well established in industry that how shippers and carriers execute the strategic bid, and what outcomes result, can and should influence shippers' subsequent strategic decisions. See, for example, industry-partnered reports such as Alnajdawi and Lopez (2020), Aemireddy and Yuan (2019), Robinson (2015, 2017a, 2017b, 2017c, 2017d), Bandaru and Dolci (2020), Harding (2005), Kim (2013), Liu and Miller (2021), and Pickett (2018). Future research could examine how specific operational factors that measure carrier or shipper performance should drive future strategic decisions. Both carriers' and shippers' performance should be studied to determine how the other party makes strategic decisions.

Moreover, the time- and resource-intensive strategic procurement process is known to be a pain point for shippers and carriers alike (Caplice (2022) and Zweier (2021)). This leads to potential questions on how shippers can consider carriers' past performance to reduce the size, cost, and complexity of the strategic bidding process. One path forward would be to more strategically rely on the spot market for capacity. This leads to research questions on how a shipper can do so and what are the expected implications.

Digitization of transportation procurement

Increasingly, there have been shifts toward digitization of the 3PL's freight matching process as billions of dollars have been poured into these services by outside investors and by the incumbents themselves. Industry-led reports are also underscoring these trends, for example, Convoy (2020a, 2020b), Davis and Lucido (2017), Freight Waves (2019b), Helguera Sanchez and Hendra Mukti (2018), and Heilmann and Freight (2020).

Accordingly, we recognize potential for research in the area of digitization of transportation procurement. Shippers and carriers are considering how to utilize digital matching services within their portfolio of supplier and customer bases, respectively, both at the macro (organizational) level and at the micro (lane or load) level. Some 3PLs are wondering how to incorporate the right mix of digital services and "human touch" services for their customer base. The research community has an opportunity to help practitioners address concerns regarding how digital matching platforms may impact TL procurement processes and the freight and logistics industry as a whole, both in the short- and long term. Research can help both shippers and carriers make strategic decisions on how to incorporate digital services (offered by either traditional 3PLs or new entrants) into their portfolio of partners.

Shippers' vertical integration (make) decision

As demonstrated by our summary of the literature, very little research has been done on the shippers' make decision as compared to its buy decision. Yet, that side of the shipper-carrier relationship spectrum is a major segment of the transportation system: In terms of revenue, in-house private or dedicated transportation operations was 25% larger than outsourced services in 2021 (Council of Supply Chain Management Professionals, 2022).

The shipper's make decision can take different forms. For example, large players such as Walmart, PepsiCo, AT&T, and Tyson Foods must consider the trade-offs between utilizing their own, existing fleets to ensure outstanding service levels and outsourcing TL services to access the associated economic benefits at both the strategic and execution stages. In a report prepared for the National Private Truck Council, Woodrooffe et al. (2009) benchmark the economic and operational performance of companies that operate private fleets. This suggests a useful research question to explore on what factors shippers should consider when deciding whether to implement a private fleet.

In another scenario, a shipper may have grown large enough to consider investing in a private or dedicated fleet. At this point, the fixed startup costs have not yet been incurred. The shipper would have to consider its expected demand volumes and variability, distribution network connectivity, and existing for-hire carrier costs and service levels, and then predict how vertically integrating the service would improve service level, costs, or both. Here, research could help the shipper consider how to integrate a new private fleet alongside for-hire contracts.

A valuable stream of research could also help address these concerns both at a macro (network) level and at a micro (load or lane) level by identifying segments of the shipper's business that should be served by a new private fleet. While these types of analyses are conducted routinely by consultants and 3PLs, there is room to include volume, price, and market uncertainty into the analysis. This is especially true for shippers using both dedicated and for-hire assets.

Carrier make decision

The existing academic literature has been saturated with research on carrier pricing decisions; however, our review shows that there has been limited research on the carrier's make decision. We suggest further exploration in the latter area that would help the carrier community. For example, it would be relevant for researchers to explore which market, customer, or demand factors an asset-based carrier should consider when deciding whether to fully allocate a portion of its fleet to a shipper through dedicated services. The benefits to a shipper of dedicated capacity have been demonstrated to a limited extent. The benefit to a carrier includes consistent, stable income for that segment of its assets. For such an arrangement to be profitable, the carrier must be fairly large, with some minimum fleet size to serve the dedicated business. Moreover, there are opportunity costs associated with dedicating capacity to a single shipper at a set price, such as when market prices begin to rise. How a carrier should weigh these factors has not been explored in the literature, and future studies could help them make such decisions in practice.

Methodological choices

The studies we review utilize a range of methodologies. Early work focused predominantly on analytical model formulation. This has been due to a lack of available empirical data and, as the field was still in development, the need to simplify industry challenges to provide tractable solutions that offered valuable new insights. The empirical work that emerged often relied either on aggregated macro data or on surveys and interviews reporting practitioners' perceptions and opinions, rather than measuring actual behaviors. While the latter approach has its limitations, it has been an effective tool for researchers to identify opinions within the industry and spark ideas for further exploration.

Increasingly researchers obtain industry micro data that can be used to model actors' behaviors. Certainly, empirical models are still simplified versions of real-world

contexts. However, given the behavioral nature of these interactions and the uncertainty we discuss in this review, we see great value in researchers expanding the existing body of knowledge through empirical methods.

The empirical approach we suggest comes with challenges. Keeping such data private is a competitive advantage for firms. Fortunately for the research community, however, many companies recognize the value of incorporating data analytics into their business decisions. Strong relationships between academics and practitioners are needed for the empirical work we propose. They are vital to inform appropriate model assumptions, select and define variable, and interpret results.

CONCLUSION

With this review, we attempt to consolidate the vast set of literature on procurement of TL services. It is a large and important piece of the U.S. economy, and one that has received well-deserved attention from academics spanning many fields. As a result, however, research in the field forms a disaggregated body of literature; it can therefore be difficult to identify areas of new research, find justifications for arguments, or demonstrate novelty of contributions to audiences that lack the contextual background of the research. With that in mind, we offer four contributions.

First, we consolidate and summarize the existing TL transportation procurement literature. To do so and also identify the gaps in the existing literature, we offer our second contribution: the formulation of a framework that is a useful tool for organizing the concepts we uncover. In addition, we demonstrate how the TL procurement research fits within and can expand upon the broader service procurement literature. Third, we summarize the research so audiences without expertise in the context of TL transportation have a single source to guide them. This can be particularly helpful to journal editors and reviewers who receive paper submissions, as it allows them to more easily identify the paper's main contributions to the field. Finally, we identify potential directions for future research and suggest research questions with which to pursue those research avenues.

ORCID

Angela Acocella https://orcid.org/0000-0002-8898-1792

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AUTHOR BIOGRAPHIES

Dr. **Angela Acocella** is a Researcher in Transportation, Logistics, and Operations at the School of Economics and Management of Tilburg University in the Netherlands. She earned her PhD from the MIT Center for Transportation & Logistics, her MSc in Technology, Policy, and Systems Engineering also at MIT, and her BSc in Mechanical Engineering from Rensselaer Polytechnic Institute. Previously, she worked as a Research Associate at Harvard Business School.

Dr. **Chris Caplice** is a Senior Research Scientist at MIT and serves as the Executive Director for the MIT Center for Transportation & Logistics. He created and leads the MITx MicroMaster's Program in Supply Chain Management. He also founded and co-directs the MIT FreightLab. Outside of MIT, he serves as the Chief Scientist for DAT Freight and Analytics.

How to cite this article: Acocella, A., & Caplice, C. (2023). Research on truckload transportation procurement: A review, framework, and future research agenda. *Journal of Business Logistics*, *00*, 1–29. https://doi.org/10.1111/jbl.12333