



## Valuation of freight transportation contracts under uncertainty

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### ABSTRACT

This paper applies concepts from the theory of Real Options to hedge uncertainty in transportation capacity and cost using derivative contracts, called truckload options. We make three contributions. First, we provide a closed-form pricing formula for basic truckload options when the truckload spot price on a given lane follows a simple mean-reverting process. Second, since only monthly statistics about truckload spot prices are currently available, we provide an approach to estimate the parameters needed to value truckload options. Finally, a numerical illustration based on real data shows that truckload options could be valuable to both shippers and carriers.

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## 1. Introduction

Uncertainties in transportation capacity and cost pose a significant challenge for both shippers and carriers in the trucking industry. One way to hedge these uncertainties is to use concepts from the theory of Real Options to craft derivative contracts, which we call truckload options in this paper. In its simplest form, a truckload call (put) option gives its holder the right to buy (sell) truckload services on a specific route, at a predetermined price on a predetermined date. The holder decides if a truckload option should be exercised depending on information available when the option expires.

Truckload options are not yet available, however, so the purpose of this paper is to develop a truckload options pricing model and to show the usefulness of truckload options to both shippers and carriers. Since the price of a truckload option depends on the spot price of a truckload, we first model the dynamics of spot rates using a common stochastic process and develop explicit pricing formulas for truckload calls and puts.

Unlike financial markets where high frequency data are publicly available, spot prices for trucking services are low frequency (one price per lane per day) and private; in fact, we can only observe the following monthly spot price statistics: average, maximum, and minimum. To circumvent this difficulty, we rely on the known distributions of these statistics for the price process we consider and on maximum likelihood techniques to obtain estimates of our model parameters. A numerical illustration based on real data suggests that truckload options could be valuable to the trucking industry.

This paper is organized as follows. Section 2 presents some background information about uncertainty in the trucking industry and related contracting problems. Section 3 models the truckload price as a stochastic process and estimate parameters using statistics from the trucking spot market. Section 4 presents an approach to pricing truckload call and

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put options. Section 5 illustrates numerically the potential value of truckload options to shippers and carriers. Section 6 discusses necessary conditions for the success of truckload options, and Section 7 summarizes our conclusions.

## 2. Background

Trucking is the dominant mode of freight transportation and, according to a recent forecast by the American Trucking Association, its share of the nation's freight pool will keep on increasing: it may reach 70% by 2018, up from 69% in 2006 (American Trucking Association, 2007).

The trucking industry is divided into two sectors: private carriage and for-hire (see Fig. 1). The value of services provided by private carriage was approximately 45% of the trucking market in 2006 (Kirkeby, 2007). Since private carriage refers to drivers employed by or owned and operated by shippers, this sector is not included in the trucking contracting market. We therefore focus on the for-hire sector, which accounts for approximately 55% of the market, of which 87% come from truckload (TL) and 13% from less-than-truckload (LTL) services. In order to procure for-hire services, shippers either write long-term contracts with carriers, usually for 1 or 2 years, or outsource to common carriers that mostly operate in spot markets.

In a spot market, shipments are handled on a one time load-by-load basis. These are used to some extent by almost all shippers and carriers. Spot market contracts are short term contracts that serve unfilled or urgent demand. They are characterized by short lead times, volatile market prices and no prior contractual agreements. Spot markets, typically conducted via online marketplaces, are currently focusing on matching shipper demand and carrier capacity. Unlike financial spot markets, on-line trucking marketplaces do not publish transaction price, but only provide some periodic price statistics. Still, a spot market is a convenient institution to procure truckload services for unexpected and urgent delivery. In fact, some firms with large private fleets, like Wal-Mart, also procure truckload services in the spot markets for their unexpected needs (Caplice, 2007).

However, the spot price of a truckload is typically much higher than the corresponding long-term contract price. In addition, service availability, in terms of time and volume, is not guaranteed to satisfy unexpected and urgent needs. Dealing with orders that require rapid and reliable delivery presents challenges for shippers at a time when the volume for this type of orders has significantly increased due to the adoption of demand responsive logistics. While shippers are concerned with guaranteed truckload services to satisfy uncertain demand, they increasingly depend on spot market procurement, which results in higher transportation costs.

Therefore, the problem of interest is how to deal with uncertainty in the demand and supply for truckload services. In this paper, we propose truckload options for specific shipping lanes. As mentioned in the introduction, a truckload call (put) option gives the holder the right to buy (sell) the right to transport a truckload between two points, at a predetermined delivery price, on or before a predetermined date. The predetermined price is referred to as the strike or exercise price; the predetermined date is known as the expiration or maturity date. A basic option can either be American or European. An American option can be exercised anytime up to its expiration date whereas a European option can only be exercised on its expiration date. Since it offers more flexibility, an American option is more valuable. In this paper, however, we consider only European options.

Using options to hedge uncertainties has begun to attract attention. After examining electronic markets for truckload transportation, Caplice (2007) points out that current knowledge should allow the expansion of spot rates and permit the creation of more flexible contracts. Tibben-Lembke and Rogers (2006) present a general framework for using options in logistics for a variety of transportation modes. They conclude that the key to making options attractive is the ability to price them. Tsai et al. (2008) reached the same conclusion in the context of truckload options. However, none of the published papers we found develops pricing models, so our goal here is to develop truckload options pricing formulas to show the potential usefulness of options to the trucking industry.

An issue of particular importance here, compared to established spot markets for various commodities, is that spot prices for trucking services are not public. When a quote is requested, an electronic marketplace typically provides some data with a note asking the shipper to contact their representative for finalizing the price (this is the case for freightquote.com or

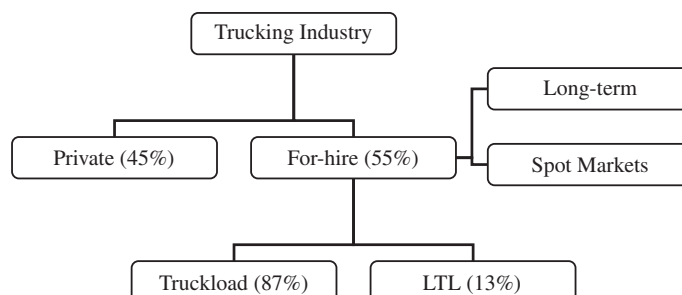


Fig. 1. Structure of the trucking industry.

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