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# Transportation Research Part A

journal homepage: [www.elsevier.com/locate/tra](http://www.elsevier.com/locate/tra)

## A forecasting approach for truckload spot market pricing

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### ARTICLE INFO

#### Article history:

Received 27 March 2016

Received in revised form 18 October 2016

Accepted 5 January 2017

#### Keywords:

Price forecasting

Highway transportation

Artificial neural network

Quantile regression

Truckload spot market pricing

### ABSTRACT

Logistics is an important sector considering the increasingly competitive nature of industry today. Large-scale companies and third-party logistics providers want the most economical and reliable forecasting mechanism for pricing the truckload spot market in the sphere of logistics and supply chains. This paper investigates the price forecasting of the truckload spot market, which is an important area for the determination of future value from the viewpoint of truckers by considering comprehensive variables. Two methodologies are used to determine truckers' spot price in the freight transport process, which are the artificial neural network and quantile regression, and a price forecasting framework is created. The framework is applied to two approaches: a route-based model and a general model in which all routes are considered together. Real data are used to demonstrate the applicability and feasibility of the proposed method. In this scope forecast performances can be assessed, the best methodology and approach can be selected, and projections can be carried out.

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## 1. Introduction

The logistics sector is an ever-growing industry throughout the world. A robust logistics sector is one of the common features of industrialized countries. The main reason behind highway transportation being the major component of the logistics sector is that the sector is closely associated with other sectors. From this perspective price forecasting for the truckload spot market in the logistics sector has been an essential field of research recently.

It has been an area of interest for decision makers and managers of companies to make predictions for the future in any sector in which uncertainty exists. Price forecasting has great importance, particularly in the case of decision making regarding a new area and an investment in economic terms.

Price forecasting of the truckload spot market in the logistics sector is one of the critical areas of decision making for the determination of future value from the viewpoint of truckers. From this perspective price forecasting in the truckload spot market is especially important to predict price fluctuations in the short term and to protect third-party providers from potential risks and crises. Moreover, large companies can plan their budgets according to the price information. At this stage one of the essential points is to create a price forecasting model addressing all the variables affecting it, in which the customer and the trucker can find common ground. This study used two methodologies to determine truckers' spot price in the freight transport process, and it created a price forecasting framework. The first model created in the price forecasting system is a quantile regression, one of the econometric models. The second method used in the study is artificial neural

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network, an artificial intelligence method. Truckers' price varies depending on several factors, such as the type of transportation, departure and arrival cities, road conditions, type of route, amount of freight, and location difficulty level.

The objective of this study is to develop a framework for forecasting the truckload spot market price in the logistics sector, to offer existing customers the most economical and high-quality services, to forecast the short- and long-term risks and price fluctuations that may be faced in the sector, and to design an effective model to determine the acceptable price levels of truckers. The designed price forecasting approach will ensure that the performance and forecast levels of both the artificial intelligence and the econometric model can be compared. In this scope two different price forecast models will be formed, the output performances will be assessed, the best methodology will be selected, and projections will be carried out.

The main aim is to determine the price information dynamically, accurately, and in an expeditious and reliable manner, thus improving the quality and performance criteria in the truckload spot market, minimizing the uncertainties, risks, and errors that may be faced in the future, preventing price fluctuations, and ensuring the most economical and reliable decision support mechanism in the sphere of logistics and supply chains. From the managerial perspective, forecasting methods give projections that rely on the strength of past data, so business executives can obtain a mixture consisting of raw data and personal impressions to develop a useful forecast. This means that businesses can use the method to make decisions about their future. Managers can design possible future outcomes for their business. Different aspects of management can be considered, such as creating, developing, producing, and adding value for the organization.

The paper has two objectives. Firstly, the price forecasting approach is developed with two methods. The quantile regression and the conventional back-propagation neural network (BP) models are used to forecast the price of highway transportation. The mean absolute percentage error (MAPE) is used to assess the forecast performance of the two methods. Secondly, the models are applied to two concepts: a route-based model and a general model in which all routes are assessed together.

By using the developed price forecasting approach, uncertainty and risk factors can be eliminated and proper price information can be gained. Thus, an economical and sustainable supply chain network design can be achieved.

The rest of this paper is organized as follows. In Section 2 the literature regarding price forecasting models is presented. In Section 3 the artificial neural network and quantile regression methodologies are explained. The application to a company in the logistics industry in Turkey is discussed in Section 4. The analysis and results are provided in Section 5, and finally Section 6 concludes the paper.

## 2. Literature review

In recent years authors have focused on modeling and forecasting financial series and prices, since they are crucial for the value of assets and the analysis of potential market characterization. Numerous studies include price forecasting; moreover, the analysis of price, future price, and volatility has become a major research area nowadays (Kristjanpoller and Minutolo, 2015).

However, there are limited resources on price forecasting using artificial neural networks (ANNs). ANNs have become popular for analyzing financial time series as they move from simple pattern recognition to a diverse range of application areas (Patterson, 1996). Other points of superiority are ANNs' capability to cover a greater range of problem complexity and their practical ease of implementation with flexibility (Trippi and Turban, 1996). The neural network forecasting research has mostly considered hybrid methodologies. Some relevant studies of forecasting are presented below.

Haofei et al. (2007) created a multi-stage optimization approach (MSOA) to forecast the Chinese food grain price. The back-propagation (BP) algorithm for training a neural network and ARIMA (Autoregressive Integrated Moving Average) methods were used. The results showed that the MSOA model is more accurate than the traditional ARIMA model or conventional BP model according to the error measures, such as the mean absolute error (MAE), mean squared error (MSE), and mean absolute percentage error (MAPE). Kristjanpoller and Minutolo (2015) proposed a hybrid ANN-GARCH (Generalized Autoregressive Conditional Heteroscedasticity) model, which is applied to forecast the gold spot and future price as well as volatility. The results showed that the ANN-GARCH hybrid system achieves an improvement in forecasting compared with the GARCH method alone. It was realized that the MAPE value can be decreased by 25%. Jammazi and Aloui (2012) developed a hybrid model by combining the dynamic properties of a multilayer back-propagation neural network and the recent Harr A trous wavelet decomposition (HTW-MBPNN); this hybrid model was applied to the prediction of the crude oil price. Tsaih et al. (1998) presented a hybrid artificial intelligence integrating the rule-based system technique and the neural network technique to predict accurately the direction of daily price changes in S&P 500 stock index futures. Kodogiannis and Lolis (2002) created a system that consists of a neural network and fuzzy models for exchange rate prediction. Wang and Leu (1996) developed a hybrid model to forecast the mid-term price trend of the Taiwan stock exchange weighted stock index. Wilson et al. (2002) considered the ANN methodology to forecast residential property prices. The results were validated using the RMSE (root mean squared error). Movagharnjad et al. (2011) used an ANN to forecast the crude oil prices over the period from January 2000 to April 2010.

It should be noted that quantile regression technique which was developed by Koenker and Bassett (1978), is also widely used for price forecast. Quantile regression was first introduced as a robust regression method, neglecting the assumption that error terms are normally distributed, which is a classical assumption in regression models. Quantile regression models are used to forecast the conditional mean functions and conditional quantile functions. Quantile regression is a generalized

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