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RESEARCH PAPER

# Competition Model of Container Road Transportation Market

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**Abstract:** Considering two major factors of truck transportation service and freight forwarding quote to the sensitive shipper, this study proposes a market competition model of container road transportation. The model involves more competitive truck operators and one freight forwarder and solves the game equilibrium through backward induction. The results indicate that with application of value-added service, truck operators receive lower profit due to burden cost of the upgrading service. However, the demand satisfaction of truck transportation market significantly increased, and the overall profit of truck operators and freight forwarder witnessed an increasing trend. Therefore, to motivate value-added service of truck operator, the reasonable benefit distribution mechanism needs to be established between truck operators and freight forwarder, which provides benefits for the healthy development of truck operator and container transportation chain.

**Key Words:** road transportation; competition model; game equilibrium; price competition; value-added service

## 1 Introduction

Since the late 1990s, the Far East region has recorded vigorous economic growth. Particularly in China, many container ports have promptly improved their infrastructure, leading to a rapid increase of container throughput. The throughput of the Shanghai port reached 31.739 million twenty-foot equivalent units (TEUs) in 2011, ranking it the largest container port in the world. Meanwhile, the container road transportation industry accounts for about 60 percent of the throughput of the Shanghai port, becoming an important force for constructing the Shanghai International Shipping Center. Up to the end of 2011, a total of 1,112 container road transportation enterprises had been registered in Shanghai consisting of 17,725 container trucks. Because the world financial crisis greatly impacted the international shipping market, coupled with oil prices increasing and market bargaining power decreasing, the profit margin of the container road transportation industry continues to decline. Situated at the end of the container transportation chain, the container road transportation industry is plunging into an unprecedented development predicament with the market viability declining and price competition accelerating.

Previous studies focused on members of the industry chain, which achieve vertical coordination by transferring prices or signing formal agreement and other related measures, which were primarily based on a single-echelon environment[1,2]. Research on the horizontal competition between two or more producers can be traced back to the classic economic model[3]. Tsay and Agrawal[4] studied a distribution system in which a manufacturer supplied a common product to two independent retailers, who in turn used the service as well as the retail price to directly compete for customers. They examined the drivers of each strategy, and the consequences for total sales, market share, profitability showing that the relative intensity of competition with respect to each competitive dimension played a key role, as did the degree of cooperation between the retailers. Bernstein and Federgruen[5] addressed infinite-horizon models for oligopolies with competing retailers under demand uncertainty. They also characterized the equilibrium behavior which arose under simple wholesale pricing schemes. Boyaci and Gallgo[6] considered a market with two competing supply chains, each consisting of one wholesaler and one retailer. They also discussed the derivation of the equilibrium service strategies, resulting inventory policies, profits for each scenario and compared the equilibria

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in a numerical study. Zheng and Wang[7] analyzed the over competition phenomenon in the domestic container shipping market of China by means of the industrial organization theory and game theory, which found that Chinese overseas container shipping companies used the vertical integration strategy of price with their domestic subsidiaries in order to ensure their shares in the overseas container shipping market. Yin[8] improved the classical newsboy model by taking quantity discount and reordering into account. A series of models were developed with incentive compatibility as the fundamental lodestar and with the revenue optimization of container line and non-vessel operating common carrier (NVOCC). The simulation was also conducted to compare and analyze key factors that affect both parties' decisions. Chu[9] studied China's international container liner fares with the method of system dynamics, and found that the fare composition, demand and supply, transportation cost and government factors were the main factors that affected container liner shipping prices.

This paper presents how to achieve mutual cooperation for the container road transportation chain, providing for the healthy development of the symbiotic container road transportation market. The game equilibrium was analyzed between service improvements of truck operators and price offerings of freight forwarders. The countermeasures include strictly regulating the charge behavior of the container road transportation upstream market. Moreover, it is more important to strengthen the container road transportation market adjustment and establish an incentive mechanism promoting value-added service to replace the vicious price competition of the container road transportation market.

## 2 Modeling competitive container road transportation market

Considering a single shipper facing some customer selection factors, include the container truck transportation service and freight forwarder offer, a competitive model of the container road transportation market with truck operators and freight forwarders was applied. It assumed that the container truck operator could offer the basic transportation service and selectable value-added transportation service. To focus on transportation service competition of truck operators without considering the service that freight forwarders provide to the shipper, this paper takes into consideration the price of the truck operator.

The freight forwarder faces the following truck transportation demand function of the shipper:

$$Q_i = a_i - b_p p_i + \theta_p(p_{-i} - p_i) + b_s s_i - \theta_s(s_{-i} - s_i) \quad (1)$$

where $a$ expresses the basic demand scale of the truck transportation market, $p$ and $S$ are transportation prices provided by the freight forwarder to the shipper and the transportation service price provided by the truck operator respectively. $b_p$ and $\theta_p$ are non-negative constants that specify the sensitivity of the truck transportation market demand to the truck transportation price, specifically, the indirect price coefficient of attracting shippers from other transportation modes and the direct price coefficient due to the shipper switching transportation modes. $b_s$ and $\theta_s$ are also non-negative constants that define the sensitivity of the truck transportation market demand to transportation service, specifically the indirect shipper service coefficient of attracting shippers from other transportation modes, as well as the direct shipper switching modes.

Therefore, the profit functions of the truck operator and freight forwarder can be expressed as:

$$\prod M_i = (w_i - c_i)Q_i(p_i, p_{-i}, s_i, s_{-i}) - \eta_i s_i^2/2 \quad (2)$$

$$\prod R = \sum_{i=1}^{n}(p_i - w_i)Q_i(p_i, p_{-i}, s_i, s_{-i}) \quad (3)$$

where $c$ is the unit transportation cost of the truck operator, $w$ is the transportation price provided by the truck operator to the freight forwarder. $\eta$ represents the cost coefficient of the truck operator improving the transportation service in accordance with the law of diminishing marginal returns. Supposing two types of transportation costs are undertaken by the truck operator, that is the basic transportation cost and value-added service cost, the latter includes on-time delivery, shipment frequency, trip tracking, vehicle monitoring, compensation commitment as well as extending financial service.

## 3 Analyzing competitive container road transportation market

In the container transportation industry chain, ports and liners are situated in a strong position and the shipper and freight forwarder as customers hold the driving condition, while the truck operator is in a weak position. For this reason, the equilibrium between the truck operator and freight forwarder is solved by using the backward induction method. Firstly, according to the transportation price quoted by the freight forwarder to the shipper, the response function of the truck operator about the price and service provided to the freight forwarder and shipper is deduced. Secondly, the freight forwarder makes a decision optimization of the initial quote to shipper based on expected truck operator's response function.

### 3.1 Response function of the truck operator

After the freight forwarder preliminarily quotes the truck transportation price to the shipper, the truck operator must give the transportation price $w$ to the freight forwarder and truck transport service $S$ to the shipper:

$$w_i^* \in \arg\max_{w_i} \prod M_i(w_i, w_{-i}^*, s_i^*, s_{-i}^* \mid p_i, p_{-i}) \quad (4)$$

$$s_i^* \in \arg\max_{s_i} \prod M_i(w_i^*, w_{-i}^*, s_i, s_{-i}^* \mid p_i, p_{-i}) \quad (5)$$