Expert Systems with Applications 38 (2011) 2319–2329

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

The impact of Collaborative Transportation Management on supply chain performance: A simulation approach

Felix T.S. Chan [a,*], T. Zhang [b]

[a] Department of Industrial and Systems Engineering, The Hong Kong Polytechnic University, Hung Hom, Hong Kong
[b] Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong, Pokfulam, Hong Kong

ARTICLE INFO

Keywords:
Collaborative Transportation Management
Performance measurement
Modeling and simulation
Supply chain management
Carriers' flexibility

ABSTRACT

Collaborative Transportation Management (CTM) is based on the interaction and collaboration between trading partners and carriers participated in the supply chain, appropriate application of CTM can improve the flexibility in the physical distribution and minimize the inefficiency of supply chain management. This paper proposes new concepts of CTM and carriers' flexibility. A simulation approach is used to (i) evaluate the benefits of the proposed CTM, (ii) explain the concept of carrier's flexibility, and (iii) optimize the delivery speed capability. Based on a simple supply chain including one retailer and one carrier, three different simulation models have been developed with changeable delivery lead time as follows: (1) Unconstrained delivery speed capability without CTM. (2) Constrained delivery speed capability without CTM; and (3) Constrained delivery speed capability with CTM. Simulation results reveal that CTM can significantly reduce the retailer's total costs and improve the retailer's service level.

1. Introduction

Global logistics in business operation has been playing a critical role in responding to the even changing market demand in the world of globalization and mass customization. The efficiency and flexibility of global distribution holds the key to success in international trade. Collaborative Transportation Management (CTM) is not only a new collaboration strategy between the shipper and carrier, it is also a new business model (Feng & Yuan, 2007).

In recent years, the collaboration among disparate partners within the supply chain and e-supply chain has been widely discussed. Interestingly, the transportation and its impact on the entire supply chain have seldom been explored. For instance, two trading partners in a supply chain generally execute Collaborative Planning, Forecasting, and Replenishment (CPFR), in order to improve the inventory cost, revenue and service. However, the connection with transportation and distribution management is often neglected. Consequently, the missing link of transportation blurs the lines between planning and execution of the supply chain. The financial and operational performances for the sellers' and the buyers', therefore, would be highly affected (Bishop, 2004; Browning & White, 2000).

Can the replenishment appear at the right time and in the right place? Often, the order is in the process, but its status is unknown due to unavailable carrier capabilities or delayed resulted from low carriers' flexibility. In a high changing demand market, retailers must suffer from high backorders of customer's demand with high penalty cost. Another consequence is to increase transportation costs by using secondary carriers, whose contract rates are not as advantageous as primary carriers. In order to minimize the inefficiency of transportation caused by insufficient interaction and collaboration, trading partners of the supply chain should consider transportation management as part of the collaboration. Through the integration and cooperation of the buyer, seller and carrier, the flexibility and overall value of business chain would be enhanced.

In this paper, a simple supply chain with stochastic market demand will be developed including one retailer and one carrier. Three different simulation models allowing changeable delivery lead time will be built which present three different simulation scenarios: (1) unconstrained delivery speed capability without CTM; (2) constrained delivery speed capability without CTM; and (3) constrained delivery speed capability with CTM. Different performances of the above situations will be analysis and discussed, including retailer's total cost and service level. The three simulation scenarios in this paper are similar as Feng et al. (2005), but the simulation models, software used to build the model and indicators to measure the performance are totally different. The delivery capability changeable in our model is the

* Corresponding author. Tel.: +852 2766 6605.
E-mail addresses: mffchan@inet.polyu.edu.hk (F.T.S. Chan), tingzhang930@yahoo.com.cn (T. Zhang).

0957-4174/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2010.08.020

delivery speed capability which is measured by delivery lead time; the shorter the lead time, the higher the capability. While, the models built by Feng et al. (2005) allowed the changeable delivery amount, the reason of which is they focused on minimizing the inventory and the holding cost. While, one focus of this paper is to minimize the penalty cost caused by the backorder of customer's demand, therefore the indicators to measure the performance in our simulation models are the retailer's total cost, including penalty cost, inventory holding cost and order cost, and the retailer's service level.

Another main contribution of this paper is the proposal of a new concept of carrier's flexibility. Simulation models built in this paper also explain the new concept of carrier's flexibility which starts with order/shipment forecasts including capabilities of planning and scheduling. Briefly speaking, the main idea of carrier's flexibility is adjustment of the planned delivery capabilities to match the changing demand. When the demand exceeds the planned capability of the carriers', carriers can adjust the delivery planning strategy with CTM so that the available delivery capability can meet the demand. They can even adjust the available delivery capability to the maximum delivery capability, in order to reduce the gap between planned delivery capability and available delivery capability.

This paper consists of five sections. Section 1 is an introduction. The Section 2 is the review of related literatures. Section 3 is the development of three models of supply chain with CTM. Section 4 is the analysis of simulation results, and finally Section 5 presents the conclusion and suggests the future research.

2. Literature review

2.1. CTM

2.1.1. Definition of CTM

According to the Collaborative Transportation Management White Paper (2004), CTM is defined as a holistic process that brings together supply chain trading partners and service providers to drive inefficiencies out of the transport planning and execution process.

Not only is CTM a new partner strategy between the shipper and carrier, it is also a new business model. This model includes the carrier as a strategic partner for information sharing and collaboration in the supply chain. The application of CTM promises to reduce transit times and total costs for the retailer and its suppliers while increasing asset utilization for the carriers. The programs benefits all three parties involved: the retailer, the supplier and the carrier (Tyan, Wang, & Du, 2003).

2.1.2. Objective of CTM

The objective of CTM is to improve the operating performance of all parties involved in the relationship by eliminating inefficiencies in the transportation component of the supply chain through collaboration. Transportation service represents a major component of order lead time—the time that elapses from an order placement until the goods are ultimately delivered to a customer. Much of the variability in order lead time is attributed to variation in transit times. With more and more companies operating on a just-in-time basis, there is less room for error in the delivery process (CTM White Paper, 2004).

It is important for companies to work together to eliminate inefficiencies, reduce cost, and ensure excellence in the movement of goods. In order to achieve the positive results of CTM, the processes between participating companies should be in real time, extendible, automated and cost-effective (Rabinovich, 2005).

2.1.3. Simulation of CTM

Feng et al. (2005) developed a modified simulation model of the "beer game", allowing the changeable delivery capacity. The supply chain performance indicators that they measured are total supply chain costs, including inventory costs and backlog costs, and transportation capacity utilization. Results of the simulation reveal that CTM can significantly reduce the total supply chain costs and improve transportation capacity utilization.

The three simulation scenarios presented in this paper are similar as Feng et al. (2005), but the simulation models, software used to build the model, and indicators to measure the performance are totally different.

(a) The inventory policy considered here is the continuous review policy or the "s-S" policy or the fixed quantity policy.
(b) The delivery capability changeable in our proposal models is the delivery speed capability which is measured by delivery lead time; the shorter the lead time, the higher the capability. While, the delivery amount is fixed.
(c) The indicators to measure the performance in simulation models are the retailer's total cost, including inventory holding cost, penalty cost and order cost, and retailer's service level.
(d) One objective in this paper is to minimize the penalty cost caused by backorder of customer's demand instead of the minimizing inventory level.

2.2. Supply chain collaboration

2.2.1. Definition of supply chain collaboration

Supply chain collaboration is prevalent in today's business model. An organization not only optimizes itself but also collaboratively with other organizations to have larger optimization planning (Chan, Chung, & Wadhwa, 2004). In order to achieve an integrative settlement, collaboration has been defined as an attempt to fully satisfy the concerns of the parties involved in exchange (Esper & Williams, 2003). The process of collaboration, pointed by several authors, is the decision making among interdependent parties (Jiang & Jiang, 2005; Koulinitch & Sheremetov, 1998; Kwon & Lee, 2002). It involves joint ownership of decisions and collective responsibility for outcomes (Stank, Keller, & Daugherty, 2001). The key characteristics of collaboration identified are coherence, communication, task management, resource management, schedule management, and real-time support (Graham, 2006).

Basically, there are three types of collaborations: the horizontal, vertical and lateral collaborations (Hsu & Hsu, 2009). The type of collaboration is mainly decided by the collaboration scenario and the attributes of the participants. Each type of collaborations is defined below:

- Horizontal collaboration: occurs when two or more unrelated or competing organizations cooperate to share their private information or resources, such as joint distribution centers.
- Vertical collaboration: occurs when two or more organizations such as the manufacturer, the distributor, the carrier and the retailer share their responsibilities, resources, and performance information to serve relatively similar end customer.
- Lateral collaboration: aims to gain more flexibility by combining and sharing capabilities in both vertical and horizontal manners.

As pointed out by Thomas and Griffin (1996), collaboration is creating significant value in the relationships along the value chain. Many studies have also discovered positive impact of strategic alliance between enterprises on their market performance