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The application of third party logistics to implement the Just-In-Time system with minimum cost under a global environment

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ABSTRACT

The integration of the Just-In-Time (JIT) system with supply chain management has been attracting more and more attention recently. Within the processes of the JIT system, the upstream manufacturer is required to deliver products using smaller delivery lot sizes, at a higher delivery frequency. For the upstream manufacturer who adopts sea transportation to deliver products, a collaborative third party logistics (3PL) can act as an interface between the upstream manufacturer and the downstream partner so that the products can be delivered globally at a lower cost to meet the JIT needs of the downstream partner. In this study, a quantitative JIT cost model associated with the application of third party logistics is developed to investigate the optimal production lot size and delivery lot size at the minimum total cost. Finally, a Taiwanese optical drive manufacturer is used as an illustrative case study to demonstrate the feasibility and rationality of the model.

1. Introduction

With the globalization of businesses, the on-time delivery of products through the support of a logistics system has become more and more important. Global corporations must constantly investigate their production systems, distribution systems, and logistics strategies to provide the best customer service at the lowest possible cost.

Goetschalckx, Vidal, and Dogan (2002) stated that long-range survival for international corporations will be very difficult without a highly optimized, strategic, and tactical global logistics plan. Stadtler (2005) mentions that the activities and processes should be coordinated along a supply chain to capture decisions in procurement, transportation, production and distribution adequately, and many applications of supply chain management can be found in the literature (e.g. Ha & Krishnan, 2008; Li & Kuo, 2008; Wang & Sang, 2005).

Recently, the study of the Just-In-Time (JIT) system under a global environment has attracted more attention in the Personal Computer (PC) related industries because of the tendency towards vertical disintegration. The JIT system can be implemented to achieve numerous goals such as cost reduction, lead-time reduction, quality assurance, and respect for humanity (Monden, 2002). Owing to the short product life cycle of the personal computer industry, downstream companies usually ask their upstream suppliers to execute the JIT system, so that the benefits, like the risk reduction of price loss incurred from inventory, lead times reduction, on-time delivery, delivery reliability, quality improvement, and lowered cost could be obtained (Shin, Collier, & Wilson, 2000). According to the JIT policy, the manufacturer must deliver the right amount of components, at the right time, and to the right place (Kim & Kim, 2002). The downstream assembler usually asks for higher delivery frequency and smaller delivery lot sizes so as to reduce his inventory cost in the JIT system (Kelle, khateeb, & Miller, 2003). However, large volume products are conveyed using sea transportation, using larger delivery lot sizes to reduce transportation cost during transnational transportation. In these circumstances, corporations often choose specialized service providers to outsource their logistics activities for productivity achievement and/or service enhancements (La Londe & Maltz, 1992). The collaboration of third party logistics (3PL) which is globally connected to the upstream manufacturer and the downstream assembler will be a feasible alternative when the products have to be delivered to the downstream assembler through the JIT system. In this study, the interaction between the manufacturer and the 3PL will be discussed to figure out the related decisions such as the optimal production lot size of the manufacturer and the delivery lot size from the manufacturer to the 3PL, based on its contribution towards obtaining the minimum total cost. In addition, the related assumptions and restrictions are deliberated as well so that the proposed model is implemented successfully. Finally, a Taiwanese PC-related company which practices the JIT system under a global environment is used to illustrate the optimal production lot size and delivery lot size of the proposed cost model.

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2. Literature review

The globalization of the network economy has resulted in a whole new perspective of the traditional JIT system with the fixed quantity-period delivery policy (Khan & Sarker, 2002). The fixed quantity-period delivery policy with smaller quantities and shorter periods is suitable to be executed among those companies that are close to each other. However, it would be hard for the manufacturer to implement the JIT system under a global environment, especially when its products are conveyed by transnational sea transportation globally. Therefore, many corporations are trying to outsource their global logistics activities strategically in order to obtain the numerous benefits such as cost reduction and service improvement. Hertz and Alfredsson (2003) have stated that the 3PL, which involves a firm acting as a middleman not taking title to the products, but to whom logistics activities are outsourced, has been playing a very important role in the global distribution network. Wang and Sang (2005) also mention that a 3PL firm is a professional logistics company profiting by taking charge of a part or the total logistics in the supply chain of a focal enterprise. 3PL also connects the suppliers, manufacturers, and the distributors in supply chains and provide substance movement and logistics information flow. The core competitive advantage of a 3PL firm comes from its ability to integrate services to help its customers optimize their logistics management strategies, build up and operate their logistics systems, and even manage their whole distribution systems (Wang & Sang, 2005).

Zimmer (2001) states that production depends deeply on the on-time delivery of components, which can drastically reduce buffer inventories, when JIT purchasing is implemented. When the manufacturer has to comply with the assembler under the JIT system, the inventories of the manufacturer will be increased to offset the reduction of the assembler's inventories (David & Chaime, 2003; Khan & Sarker, 2002; Sarker & Parija, 1996).

The Economic Order Quantity (EOQ) model is widely used to calculate the optimal lot size to reduce the total cost, which is composed of ordering cost, setup cost, and inventory holding cost for raw materials and manufactured products (David & Chaime, 2003; Kelle et al., 2003; Khan & Sarker, 2002; Sarker & Parija, 1996). However, some issues such as the integration of collaborative 3PL and the restrictions on the delivery lot size by sea transportation are not discussed further in their studies. For the above involved costs, David and Chaime (2003) further discuss a vendor–buyer relationship to include two-sided transportation costs in the JIT system. Koulamas (1995) and Otake et al. (1999) describe that the annual setup cost is equal to the individual setup cost times the total number of orders in a year. McCann (1996) and Tyworth and Zeng (1998) both state that the transportation cost can be affected by freight rate, annual demand, and the products' weight. Compared to the above studies which assume that the transportation rate is constant per unit, Swenseth and Godfrey (2002) assumed that the transportation rate is constant per shipment, which will result in economies of scale for transportation. Besides, McCann (1996) presented that the total logistics costs are the sum of ordering costs, holding costs, and transportation costs. A Syarif, Yun, and Gen (2002) mention that the cost incurred from a distribution center includes transportation cost and operation cost. Taniguchi, Noritake, Yamada, and Izumitani (1999) states that the costs of pickup/delivery and land-haul trucks should be included in the cost of the distribution center as well.

The numerous costs involved will be formulated in different ways when the manufacturer operates the JIT system associated with a collaborative 3PL under a global environment. Kreng and Wang (2005) presented a cost model, which can be implemented in the JIT system under a global environment, to investigate the most appropriate mode of product delivery strategy. They discussed the adaptability of different transportation means for different kinds of products. In this study, the implementation of sea transportation from the manufacturer to the 3PL provider will be particularized, and the corresponding cost model will also be presented to obtain the minimum total cost, the optimal production lot size, and the optimal delivery lot size from the manufacturer to the 3PL provider. Finally, a Taiwanese company is used for the case study to illustrate and explore the feasibility of the model.

3. The formulation of a JIT cost model associated with the 3PL

Before developing the JIT cost model, the symbols and notations used throughout this study are defined below:

B 3PL's pickup cost per unit product (amount per unit)
C_j 3PL's cost of the jth transportation container type, where $j = 1, 2, 3, \ldots, n$ (amount per year)
D_P annual demand rate of the product (units per year)
D_r annual demand of raw materials (units per year)
D customers' demand at a specific interval (units per shipment)
E annual inventory holding cost of 3PL (amount per year)
F_j transportation cost of the jth transportation container type from the manufacturer to the 3PL, where $j = 1, 2, 3, \ldots, n$ (amount per lot)
F freight rate from the 3PL provider to the assembler (amount per kilogram)
H_p inventory holding cost of a unit of the product (amount per year)
H_r inventory holding cost of raw materials per unit (amount per year)
I_j average product inventory of the jth transportation container type in the manufacturer, where $j = 1, 2, 3, \ldots, n$ (amount per year)
I annual profit margin of 3PL (%)
K ordering cost (amount per order)
k_j number of shipments from the 3PL provider to the assembler when the delivery lot size from the manufacturer to the 3PL provider is Q_j with the jth transportation container type, where $j = 1, 2, 3, \ldots, n$ $(k_j = Q_j/d)$
M^* optimal number of shipments that manufacturer delivers with the optimal total cost
M_j^* actual number of shipments of the jth transportation container type with the minimum total cost, where $j = 1, 2, 3, \ldots, n$
m_j number of shipments of the jth transportation container type, where $j = 1, 2, 3, \ldots, n$
m_j^* number of shipments of the jth transportation container type with the minimum total cost, where $j = 1, 2, 3, \ldots, n$
N^* optimal production lot size of the manufacturer (units per lot)
N_j^* optimal production lot size of the jth transportation container type, where $j = 1, 2, 3, \ldots, n$ (units per lot)
N_j production lot size of the jth transportation container type, where $j = 1, 2, 3, \ldots, n$ (units per lot)
N_r ordering quantity of raw material (units per order)
P production rate of product (units per year)
Q_j maximum delivery lot size of the jth transportation container type, where $j = 1, 2, 3, \ldots, n$ (units per lot)
q^* optimal delivery lot size of the manufacturer (units per lot)
q_j actual delivery lot size of the jth transportation container type, where $j = 1, 2, 3, \ldots, n$ (units per lot)
R_j loading percentage of the jth transportation container type, where $j = 1, 2, 3, \ldots, n$ $(R_j = q_j/Q_j)$
r_j real number of shipments from the 3PL provider to the assembler when the delivery lot size from the manufacturer to the 3PL provider is q_j with the jth transportation container type, where $j = 1, 2, 3, \ldots, n$ $(r_j = q_j/d)$