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Payment schemes for a two-level consignment stock supply chain system

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ABSTRACT

Inventories account for almost 50% of the total logistics costs of a supply chain. Therefore, managing inventories helps organizations to reduce costs, increase profits, and satisfy customers' demand. Different inventory models have been developed to solve transportation and warehousing issues. These models help in optimizing different supply chain systems and maximizing their total profits. Coordinating orders between players has been shown to be profitable. A Consignment Stock (CS) agreement as a coordination mechanism has been receiving attention from practitioners and academicians. This paper reflects one reality of CS agreements and investigates the effects of four different payment schemes on the total profit of the system when a consignment stock agreement is adopted between a vendor and a buyer. The results showed that adopting a scheme that makes frequent and equal payments is often better than the other payment schemes compared in this paper. It was also shown in the paper that finding the optimum number and size of payments enhances the performance of the supply chain system and its total profit.

1. Introduction

In recent times, researchers and managers focused on studying and adopting new strategies for improving the performance of organizations and customer satisfaction. Supply chain management (SCM) generally has been a successful strategy in improving the performance of a single company or a chain that consists of different companies working or partnering together toward providing the end customer with finished products (Stadtler, 2008).

In supply chains, inventories account for almost 50% of the total logistics costs of a supply chain (Jaber & Zolfaghari, 2008), and managing inventories has many benefits such as lowering costs and improving profits and customers' satisfaction. Different types of coordination mechanisms have been developed to integrate the inventory and logistics activities of players in supply chains, enhance the performance of the system and reduce the total system costs. Some of these mechanisms are vendor managed inventory (VMI) systems, collaborative planning, forecasting and replenishment (CPFR), and consignment stock (CS) (Ryu, 2006). This paper focuses on one of these mechanisms, which is the consignment stock (CS).

CS is one type of the coordination mechanisms that has been practiced in industry. It is "an innovative approach to manage inventories in which the vendor removes its inventory and maintains a stock of materials at the buyer's plant." (Battini, Gunasekaran, Faccio, Persona, & Sgarbossa, 2010b, p. 477). CS is also known as supplier owned inventory (SOI) (Piplani & Viswanathan, 2003) or consignment inventory (CI) (Gümüş, Jewkes, & Bookbinder, 2008). Many businesses, such as hospitals, clothing and furniture retailers, some gas stations, bookstores, sport equipment and musical instruments' stores, have started to adopt CS agreements (Sarker, 2014). In a CS agreement, the products are owned by the vendor (an upstream player) and stored at the buyer's warehouse (a downstream player). The buyer uses or sells the products from the consigned inventory and then pays the vendor for the quantities that have been withdrawn. Looking at different consignment stock contracts, one can realize that it is the responsibility of the buyer to maintain and manage the products that are stored in its warehouse facility. The consignment stock has to be stored separately from the buyer's stock so it can be tracked easily and accurately. In addition, it is the responsibility of the buyer to insure the products against theft, damage, and loss. Moreover, the buyer has to inspect the items once it received them and report any damages directly to the vendor so as to avoid any additional charges. Furthermore, it is the responsibility of the buyer to send a regular usage report to the vendor showing the

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quantities that have been used from inventory and to place orders to replenish its stock. This is one of the differences between the CS and the VMI. Additionally, the vendor is the one that usually decides and controls the selling price. The buyer makes its profit from selling the items, usually through a mark-up of the buyer's (vendor's) purchasing (selling) price that both parties have agreed to upon signing the contract. Although the buyer has to manage and take responsibility for all of the above, it is the responsibility of the vendor to remove or replace any unused, unsold or expired products, which is in the favor of the buyer especially if the product is new in the market or has a short lifespan. Finally, both parties, the vendor and the buyer, have to perform a periodic review or audit that could be weekly, monthly, quarterly or annually in order to count the items in stock and to compare what is there with the usage reports that have been sent by the buyer. Any discrepancy between the amount stocked and that reported is charged to the buyer.

Although consignment stock has been practiced for some time, Braglia and Zavanella (2003) were the first to analytically investigate the consignment stock policy for controlling inventories in a two-level (a vendor and a buyer) supply chain system. They also highlighted its benefits and the areas where it could be applied. Braglia and Zavanella (2003) mentioned that the buyer pays the vendor whenever the consigned item is used or sold, which may be impractical. To address this limitation, this paper investigates the effects of different payment schemes and other cost factors, which were adopted from real consignment stock contracts/agreements, on the total profit of the system operating under CS, described in Braglia and Zavanella (2003), in order to reflect the reality of this type of contract.

The rest of this paper is divided as follows: Section 2 is for literature review, Section 3 summarizes components of real consignment stock contracts, Section 4 is for assumptions and notations, Section 5 is for model development, Section 6 presents the solution procedure, Section 7 provides a numerical example, Section 8 is for profit sharing scenarios, Section 9 performs a sensitivity analysis, and the paper ends with Section 10, which is for summary, conclusions and future work.

2. Literature review

There are many studies that have been published to cover different elements along the area of supply chain management. Most of these studies focused on developing coordination mechanisms that help in increasing the performance of a chain and reducing (increasing) its total costs (profits). Simatupang, Wright, and Sridharan (2002) divided the coordination mechanisms into four main modes: logistics synchronization, information sharing, incentive alignment, and collective learning. The first mode, logistics synchronization, helps improve the performance and efficiency of a supply chain by recognizing the changes in customers' demand, improving inventory management, facility and transportation among the players in a supply chain, reducing the forecasting errors and satisfying the customers, lowering the cost of the inventory, and improving the availability of the product (Lambert, Stock, & Ellram, 1998). The second mode, information sharing, focuses on sharing the necessary and important data that is available or known to the downstream end of a supply chain, with the upper players. The third mode, incentive alignment, shows how one player in a supply chain is going to be rewarded or penalized based on the decision that is made. Collective learning, the fourth and last mode, considers the knowledge that one player has to transfer to other parties in a supply chain so as to accomplish ongoing improvements that enhance the performance of a chain (Simatupang et al., 2002).

In the area of inventory management, Harris (1913) was the first who developed the economic order quantity (EOQ) to find the optimal lot size that reduces the sum of the holding and setup costs. The work of Harris (1913) was followed by that of Taft (1918) who developed the economic production quantity (EPQ) model, which is a modification of the EOQ model by considering finite rather than an instantaneous production rate. These models have been used by many researchers as base models to develop more realistic ones by relaxing some and adding other assumptions. Some of these models focused on studying a two-level supply chain system while others tried to go beyond by studying a system that consists of more than a three-level system (see, Glock, 2012; Jaber & Zolfaghari, 2008). In addition, some researchers studied a more complicated system by considering multiple suppliers and/or multiple buyers. These models are based on the Joint Economic Lot Sizing Problem (JELSP) initiated by the works of Banerjee (1986) and Goyal (1988), which set the foundation for the centralised coordination policy in which a decision maker (usually a group of people) determines the optimal order sizes and shipment numbers that minimize the total supply chain cost (see, Glock, 2012; Jaber & Zolfaghari, 2008). Readers may also refer to Andriolo, Battini, Grubbström, Persona, and Sgarbossa (2014), Glock, Grosse, and Ries (2014) and Bushuev, Guiffrida, Jaber, and Khan (2015) for recent and concise reviews of the EOQ/EPQ and supply chain models.

The classical JELSP approach works as follows. For example, in a simple two-level supply chain, the vendor produces and stores a lot (of a specific size) and ships it to the buyer in equal batch sizes (different from its EOQ/EPQ) at equal intervals. Savings generated from coordinating orders and shipments, when compared to the uncoordinated case, minimize the total supply chain costs. These savings are used to compensate the losing party with the remaining amount shared according to certain contracts (Jaber & Zolfaghari, 2008).

Another form of the JELSP is the consignment stock (CS) policy or agreement. The CS has been investigated by some researchers to study its benefits and drawbacks on the performance of different supply chain systems. Braglia and Zavanella (2003) used the JELSP approach to model consignment stock for controlling inventories in a two-level (a vendor and a buyer) supply chain system. They also highlighted its benefits and the areas where it could be applied. After that, Valentini and Zavanella (2003) tried to apply the consignment stock in the automotive industry to show the positive impact and the negative impact of the model. They found that the consignment stock has a positive impact on the system as it increases savings, flexibility level, service level, and enhances the collaboration as well as the relationship between parties in the chain.

The work of Braglia and Zavanella (2003) triggered several works that extended or modified it. Tang, Zanoni, and Zavanella (2007) showed how the CS policy is beneficial for both the vendor and the buyer when operating in an uncertain environment, while Persona, Grassi, and Catena (2005) considered the obsolescence of inventory. Gümüş et al. (2008) tried to develop general conditions that told when the consignment stock would be beneficial for the vendor (not the buyer), the buyer (not the vendor), and for both. Lee and Wang (2008) considered a case where the buyer's warehouse would have a specific capacity, while Huang and Chen (2009) restructured the holding cost into two components: storage and financial costs.

The above survey of models on CS considered a single vendor and a single buyer. Zavanella and Zanoni (2009) modified the work of Braglia and Zavanella (2003) to consider multiple buyers. The aim of their study was to find the optimal replenishment decision for the players. Battini et al. (2010b) considered a similar problem to that of Zavanella and Zanoni (2009) but with stochastic demand.