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The consignment stock case for a vendor and a buyer with delay-in-payments

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ABSTRACT

Inventory Management (IM) techniques help in minimizing (maximizing) the total cost (profit) of a supply chain and enhance its performance. Different models have been developed within the supply chain area to manage inventories and solve related issues (i.e. logistics and transportation). Consignment stock (CS) is an IM technique that has been shown to improve supply chain performance, where a vendor uses its buyer's warehouse to store its items. The buyer pays the vendor once the items are withdrawn from the consigned inventory. This paper investigates the CS policy in a two-level (vendor–buyer) supply chain when it is permitted to delay payments. This is a business practice found in CS contracts. An equal-interval equal-payment scheme is considered, and three scenarios of delayed payments have been developed. The first scenario (base model) does not consider delay-in-payments, where the second (interest-free) and the third (with interest) do. The results showed that offering the buyer a permissible period to settle its account is better for the system than paying the vendor at the time of the invoice. In addition, the third scenario, where the buyer pays the vendor after the permissible period and is charged interest, was shown to be the most profitable for the supply chain system considered.

1. Introduction

Supply Chain Management (SCM) is a complex topic that involves managing several functional areas within a supply chain (SCH) system to improve its performance indicators. Proper IM helps in increasing the profit (lowering the cost) of a SCH system. This led many researchers to focus on developing and investigating different inventory models and SCH coordination mechanisms that represent different inventory situations (e.g., Bushuev, Guiffrida, Jaber, & Khan, 2015) and supply chain structures of two or more levels with single or multiple entities at each level (see Glock, 2012; Jaber & Zolfaghari, 2008). One of the coordination mechanisms that have caught the attention of researchers is the consignment stock (CS), which is the focus of this paper.

In a two-level SCH with CS policy, a form of the Joint Economic Lot Size Problem (JELSP), an upstream player (vendor) produces and ships items to be stored at a downstream facility (buyer). Although the items are stored at the buyer's warehouse, it is owned by the vendor. The buyer uses or sells the items from the consigned inventory (CI) and pays the vendor for the withdrawn quantities. The first analytical work that investigated CS in a two-level SCH was introduced by Braglia and Zavanella (2003) who highlighted some of its positive and negative sides, and its applications. In a later study, Valentini and Zavanella (2003) used an industrial case from an automotive company to underline its benefits and pitfalls.

The work of Braglia and Zavanella (2003) has been extended and modified by several researchers considering different factors, some of which are reviewed here. Wang, Jiang, and Shen (2004) investigated the effect of a CS contract with revenue-sharing on the performance of a SCH system. Persona, Grassi, and Catena (2005) developed a CS model considering the effects of obsolescence, while Tang, Zanoni, and Zavanella (2007) showed the benefits of CS in an uncertain environment. Gümüş, Jewkes, and Bookbinder (2008) studied the joint effect of the CS and the vendor-managed inventory (VMI) in a two-level SCH system. Lee and Wang (2008) considered limited warehouse capacity, while Huang and Chen (2009) divided the holding cost into storage and financial components. Zanoni, Jaber, and Zavanella (2012) considered the effects of workers' learning and forgetting in a VMI with CS agreement (VMI–CS). Further research considered CS with deteriorating items when the buyer's storage capacity is limited (Wang, Lee, & Chang, 2012), disposing unsold items with a revenue sharing contract (Hu & Li, 2012), retail space allocation (Hariga & Al-Ahmari, 2013), controllable lead time (Yi and Sarker,

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2013), imperfect production process (Bazan, Jaber, Zanoni, & Zavanella, 2014), reverse logistics (Jaber, Zanoni, & Zavanella, 2014), and stock dependent demand on the number of items displayed on shelves at the buyer's facility (Zanoni & Jaber, 2015).

In a system of a single vendor with multiple buyers, Liu, Sun, and Yao (2007) studied the effect of obsolescence on the performance of the CS system, while Srinivas, Rao, and Rao (2008) formulated different CS situations of multiple decision variables and used genetic algorithm to solve them. Moreover, Zavanella and Zanoni (2009) developed a model that consists of multiple buyers, which was also considered later by Battini, Gunasekaran, Faccio, Persona, and Sgarbossa (2010), but with stochastic demand. They showed that the type of coordination and the SCH structure affect SCH profitability. In a similar scenario, Srinivas and Rao (2010) found the optimum solution for the SCH in Zavanella and Zanoni (2009) using genetic algorithm. Later, Ben-Daya, Hassini, Hariga, and Al Durgam (2013) showed the benefits of VMI and CS contracts when the vendor deals with multiple buyers. Readers may refer to Sarker (2014) for a critical review of the CS literature.

Another topic that has received significant attention in the literature is trade credit (e.g., quantity discount, price discount, delay-in-payment, etc.), as it has shown to increase sales and SCH profitability. In a vendor–buyer relationship, it is common practice that the vendor allows a permissible delay period for the buyer to settle its balance (payment). In the United States, roughly 80% of firms deals with trade credit (Tirole, 2006), and in the United Kingdom, around 80% of business transactions are ended in credit (Wilson & Summers, 2002) as it helps increase SCH profitability (Wu, Ouyang, Cárdenas-Barrón, & Goyal, 2014). Seifert, Seifert, and Protopappa-Sieke (2013) provided an excellent review of the literature on trade credit and discussed some future research opportunities. They reported that trade credit reduces transaction costs and increases sales, and how it affects order quantities, the frequency of shipments, and costs and profits. Although in CS the buyer pays the vendor after withdrawing the items from the CI, delay-in-payments can still be offered by the vendor. To illustrate, once the buyer sends a usage report to the vendor and asks for a new order, the latter invoices the buyer for the withdrawn quantities in the previous period (e.g., weeks). The buyer then has a fixed period of time from receiving the invoice to settle its payment with the vendor, as agreed to when signing the contract. Refer to Chang, Teng, and Goyal (2008), Seifert et al. (2013), and Molamohamadi, Ismail, Leman, and Zulkifli (2014) for additional readings on trade credit.

The surveyed works on CS implicitly adopted the assumption of Braglia and Zavanella (2003) that the buyer pays the vendor as items are withdrawn from inventory, which is an unrealistic and impractical assumption. Zahran, Jaber, Zanoni, and Zavanella (2015) were the first to study the effect of different payment schemes on the total profit of a SCH system with CS. They found that a scheme where equal payments are made at equal intervals is the most profitable and practical for the system. The investigation of several CS business contracts, which are available online (see i.e. Table 1, and Table A in Appendix A), showed that a payment scheme coupled with delay-in-payments is practiced by some firms, and is offered by the vendor to its buyers where it charges interest on balances past the payment due date. For instance, it is mentioned in one of the terms of LBMA's contract that the consignor (vendor) has the right to charge the consignee (buyer) an interest on balances not settled by the due date. Also, it is mentioned in the Trelleborg's contract that the vendor invoices the buyer for products purchased in the previous month, and the due date of the payment is 30 days from the invoice date. This is a real example that an equal interval invoice scheme and delay-in-payments are jointly practiced. One more example is that of CARFAC Saskatchewan Visual Artists in which the dealer has to settle its payment within 14 days of the time of the invoice. Otherwise, 12% interest rate is charged on any overdue amount until the payment is made. Moreover, in The Newcastle upon Tyne Hospitals NHS Foundation Trust contract, it is stated that the customer has to settle its account in full within 30 days from the time the customer receives the invoice in order to replenish its CS warehouse. Stone Art Manufacturing contract mentions that the payment has to be made within 7 days of the invoice date, and interest is charged for the unpaid amount. The last example in this paper is the one for NASCO Distributer Sales that allows its customer 45 days from the day of the invoice to pay. Table 1 lists few real CS contracts (exact contract closes are found in Appendix A).

Although delay-in-payments has been practiced by firms adopting CS, to the best of the authors' knowledge, no study has yet investigated the effect of the delay-in-payments on a SCH system with CS agreement. This paper builds on the work of Zahran et al. (2015) by investigating the joint effect of a permissible delay-in-payments and making frequent equal-sized payments on the total profit of a vendor–buyer SCH system operating under a CS policy.

The next section, Section 2, is for presenting the problem definition, assumptions, and notations. Section 3 is for developing the models. Section 4 presents and discusses the numerical results and compares them with the classical model. Section 5 is for the sensitivity analysis. The paper closes with Section 6, which is for summary and conclusions.

2. Problem definition, assumptions and notations

The problem consists of a vendor and a buyer that operate under a CS agreement. The vendor produces a single product at one manufacturing plant and furnishes it to a particular customer (the buyer). The vendor invoices the buyer at equal time intervals for the withdrawn quantities from the CI. The buyer's payment can either be on time (when the invoice is received) or delayed (with/without additional costs).

In order to clearly show the effect of the delay-in-payments when incorporated with the CS agreement, the following straightforward assumptions (in line with the literature) were considered when developing the models:

1. The buyer's demand is constant.
2. The buyer receives equal instantaneous shipments.
3. The vendor's production rate is constant and greater than the demand rate to avoid shortages.
4. Equal payments at equal time intervals (Zahran et al., 2015) and delay-in-payments is applied for each payment.

Table 1
Samples of real consignment stock contracts.

Name of the company	Reference to the CS contract
LBMA	http://www.lbma.org.uk/assets/LBMA%20Consignment%20Agreement%2020051219.pdf
Trelleborg	http://www.trelleborg.com.au/wp-content/uploads/2013/08/TESA-Terms-of-Sale-on-Consignment.pdf
CARFAC Saskatchewan Visual Artists	http://www.carfac.sk.ca/assets/Consignment_Agreement__2010-05-13_.pdf
The Newcastle upon Tyne Hospitals NHS Foundation Trust	http://www.newcastle-hospitals.org.uk/downloads/policies/Operational/ConsignmentStockPolicyandProcedure201307.pdf
Stone Art Manufacturing	http://www.stoneartmanufacturing.co.za/My_Homepage_Files/Download/Consignment%20Stock%20Agreement%20Revision.pdf
NASCO Distributor Sales	http://www.nascosales.com/assets/downloads/cosignment_agreement.pdf