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A one-vendor multi-buyer integrated production-inventory model: The 'Consignment Stock' case

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ABSTRACT

In recent years, companies have strengthened their supply agreements, and even the management of their inventories. To this aim, vendor-managed inventory (VMI) represents an interesting approach to stock monitoring and control, and it has been progressively considered and introduced in several companies. The research proposed investigates the way how a particular VMI policy, known as Consignment Stock (CS), may represent a successful strategy for both the buyer and the supplier.

The most radical application of CS may lead to the suppression of the vendor inventory, as this actor uses the buyer's warehouse to stock its finished products. As a counterpart, the vendor will guarantee that the quantity stored in the buyer's warehouse will be kept between a maximum level and a minimum one, also supporting the additional costs eventually induced by stock-out conditions. The buyer will pick up from its store the quantity of material needed to meet its production plans and the material itself will be paid to the buyer according to the agreement signed.

In previous studies, Braglia and Zavanella [2003. Modelling an industrial strategy for inventory management in supply chains: The 'Consignment Stock' case. International Journal of Production Research 41, 3793–3808] developed an analytical model of the CS policy, referring to a single-vendor and single-buyer situation. The same authors presented a comparison with the optimal solution available in the literature (in particular, with reference to Hill's model [1997. The single-vendor single-buyer integrated production-inventory model with a generalised policy. European Journal of Operational Research 97, 493–499]). The analytical results obtained allow the identification of the benefits and profitability that the CS approach determines in environments affected by uncertain demand.

In order to understand the potential benefits of the CS policy, an analytical model is offered with reference to the interesting industrial case of a single-vendor and multiple-buyer productive situation, thus obtaining the optimal replenishment decisions for both the vendor and buyers in such a situation. The results show how the CS policy works better than the uncoordinated optimisation.

1. Introduction

The present study makes reference to an industrial practice concerning the strategic management of inventories, known as Consignment Stock (CS). Initially, the authors observed it in a company manufacturing components for the automotive chain (Valentini and Zavanella, 2003; Braglia and Zavanella, 2003). This management strategy spread out rapidly in different manufacturing environments, confirming its strategic interest for companies and its positive attitude in being implemented in supply chains. However, the industrial implementation of CS

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agreements frequently requires the solution of some problems perceived by the two actors of the chain. In particular,

1. it is common opinion that the buyer gets the most advantages from the CS agreement, in particular when it is a large company interacting with a small–medium-sized vendor (supplier);
2. the vendor is frequently doubtful about the real advantages offered by the CS agreement, as he generally provides the same component/device to different customers and, therefore, he is unable to clearly perceive the real impact of the CS policy on his lot-sizing strategy.

The former opinion may find a further support in the need for a continuous exchange of digital information between the two actors, which generally introduces the topic of a uniform information system. Such a change may be costly for a small–medium company (in terms of personnel, too) and the opportunity of a partnership with the larger buyer may be unavoidable. The second concern refers to a situation that is extremely common in practice, e.g. when the vendor is a component or raw material manufacturer and his customers are assembly companies or manufacturers. Such a problem suggested the present analysis, which aims at investigating the single-vendor and multi-buyer environment so as to draw some managerial indications useful for understanding whether the CS policy may be successfully implemented in pyramidal chains.

According to the topics outlined, Section 2 offers the framework of the literature, so as to correctly locate the contribution in the scientific scenario. Section 3 presents the model notation and the assumptions introduced, while Section 4 focuses on the specific problem (single vendor and multi-buyer), introducing the notation and the model developed. Finally, a numerical example is proposed to validate the model and draw the managerial issues that it addresses (Section 5), and a sensitivity analysis is carried out to explore the influence of the relevant parameters (Section 6).

2. Literature review

2.1. Single-vendor single-buyer models

A large number of noticeable studies emerged in last years related to buyer–vendor coordination. In his pioneering studies (1976 and 1977), Goyal suggested a joint economic lot-size model where the objective is to minimise the total relevant costs for both the vendor and the buyer. Afterwards, the model was generalised by Banerjee (1986a, b), Goyal (1988) himself and Goyal and Gupta (1989). These models assume that a perfect balance of power exists between the vendor and the buyer, enforced by contractual agreement. However, other studies develop models, the aim of which is to minimise the vendor's total annual cost subject to the maximum cost that the buyer may be prepared to incur (e.g. Lu, 1995).

Some years later (1997 and 1999), Hill's contributions focused on a model to minimise the total costs per year of the buyer–vendor system. The basic assumption is that the vendor only knows the buyer's demand and his order frequency. Consequently, the model may be applied when co-operation between the two parties exists.

In Goyal (2000), it is possible to find an improvement to the approach for the optimal policy for a single-vendor single-buyer integrated production-inventory system considering the capacity constraint determined by the transport equipment.

Valentini and Zavanella (2003) present an industrial case and performance analysis of CS, and Braglia and Zavanella (2003) propose the related analytical approach and some performance evaluation of the CS policy. Moreover, Zanoni and Grubbström (2004) provide a full analytical solution.

Ben-Daya and Hariga (2004) relax the assumption of deterministic demand and assume that the lead time is varying linearly with the lot size. They consider the lead time composed of a lot-size-dependent run time and constant delay times such as moving, waiting and setup times.

Hoque and Goyal (2006) develop a heuristic solution procedure to minimise the total cost of setup or ordering, inventory holding and lead-time crashing for an integrated inventory system under controllable lead time between a vendor and a buyer.

Under the assumption of deterministic demand, Hill and Omar (2006) summarise the previous research on the single-vendor single-buyer integrated production-inventory problem and, additionally, provide an improvement to the CS case, offering an analytical solution that considers different batch dimensions within a replenishment cycle.

Zhou and Wang (2007) present a model, which neither requires the buyer's unit holding cost to be greater than the vendor's nor assumes the structure of the shipment policy. The model is extended to the situation with shortages permitted, based on shortages being allowed to occur only for the buyer. The paper also presents a corresponding production-inventory model for deteriorating items.

Finally, Sarmah et al. (2006) present a literature review dealing with buyer–vendor coordination models, under a deterministic environment, classifying them and identifying the critical issues and future research lines.

2.2. Single-vendor multiple-buyer models

The integrated inventory models for the one-vendor multi-buyer case have been discussed by a number of other authors. Although Lal and Staelin (1984) worked on the development of a quantity discount schedule for a vendor facing several groups of homogeneous purchasers, their model presents some shortcomings. The most important one being that, while assuming deterministically known purchaser orders, they also assume that the vendor's production policy will be unaffected by changes in the purchasers' order quantities. Joglekar (1988) pointed out that, particularly in a many-purchaser