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Integrated inventory models considering permissible delay in payment and variant pricing strategy

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ABSTRACT

The allocation of cost savings is very important for the success of the joint relationship between the buyer and vendor in supply chain management. This paper develops integrated models with permissible delay in payments for determining the optimal replenishment time interval and replenishment frequency. In addition, the variant pricing strategy is employed to obtain both sides' cost savings in order to entice buyers to join long-term cooperative relationships. A simple solution algorithm is presented to allocate the cost savings in the integration model, and a numerical example is used to demonstrate the feasibility of the proposed integration models.

1. Introduction

Facing a competitive commercial environment, many vendors and buyers would like to establish long-term cooperative relationships to obtain stable sources of supply and demand to gain the optimum profit from each other. Thus, the way to determine the optimal order quantity for the integrated vendor–buyer system has become an important issue. From the existing literature, the inventory decision-making studies that take the vendor–buyer cooperative relationship into account can be categorized into four types, with various considerations incorporated into each model. The first type of such studies presented integrated vendor–buyer models to determine the optimal order quantity under the considerations of the vendor's production rate or quantity, the distribution function of lead time, the allowable shortage, and the allowable imperfect items with works [1–8]. Although integrated models are developed in the above studies, the trade credit policy, such as the permissible delay in payments, and sharing the cost savings and profit earnings, were not considered in the models. Instead, the vendor and buyer share the cost savings from integrated models based on the proportion of both sides' total costs without integration.

The next type of models considered the vendor and buyer as a unit to determine the optimal order quantity, so that the total cost will be lower than that without integration. However, in general, the vendor's total cost decreases in the integrated model, while the buyer's one increases. Consequently, much attention has been paid to the situation when the vendor provides the buyer with preferential terms. Among the preferential terms, the price strategy is usually adopted in the literature. From the buyer's viewpoint, the order quantity is determined based on the discounted procurement cost per unit item to decrease the total cost [9]. Instead, from the vendor's viewpoint, the discount scheme is set up and implemented in the models to determine the optimal price for encouraging the buyer to increase the order quantity so as to finally increase the vendor's profit [10–12]. Recently, the price discount is regarded as an incentive to

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entice the buyer to establish long-term vendor–buyer cooperative relationships. Following such an idea, several researchers developed the integrated inventory models [13–15], in which the vendor and buyer share the joint cost savings or profits based on the coefficient of negotiation. However, the trade credit policy was not taken into account in these studies.

Traditional inventory models usually hypothesize that the buyer pays the vendor immediately when the items purchased are received. However, in practice, the vendor often gives the buyer a delay payment period to promote the buyer increasing the order quantity. Thus, within this period the buyer does not have to pay and can also deposit the sales revenue in the bank to earn interest. Therefore, the third type of vendor–buyer collaborative models consider the above trade credit policy from the buyer's viewpoint, i.e., permissible delay in payments, and possibly other matters, such as deteriorating items, allowed shortages, and the level of order quantity [16–24]. The most recent article [24] developed the model with a permissible delay in payments depending on the order quantity. However, although the policy of permissible delay in payments is included in the above models, they are not developed based on the concept of the integrated vendor–buyer.

The final type of studies proposed the integrated vendor–buyer models with the trade credit policy from both sides' viewpoints [25–29]. Some of these studies derived their models on a lot-for-lot basis. In other words, the quantity produced by the vendor depends on that ordered by the buyer, no matter what the production rate is. Among them, Chen and Kang [29] proposed integrated vendor–buyer models considering variant permissible delay in payments to determine the optimal order quantity each time and the total quantity produced by the vendor each production run. In their models, the buyer pays the total procurement cost to the vendor at the end of the compromised delay period by the sales income until the pay time and the loan from a bank.

Instead, this paper develops an integrated vendor–buyer model with a fixed delay in payments based on the credit policy that the buyer borrows the total procurement cost from the bank to pay the vendor at the end of the delay period. In addition, for sharing joint cost savings between the vendor and buyer, the variant pricing strategy is also included in the paper for the vendor to entice the buyer to join the cooperative relationship and achieve a win–win objective. In the following section, the notations and assumptions used throughout this paper for the proposed models are defined and described. Three mathematical models are derived in Section 3. Considering buyers and vendors as individuals, the buyer's optimal replenishment time interval (T) and the frequency (n) of the buyer's replenishments are determined in Model 1. Viewing the vendor and the buyer as a whole, Model 2 develops an integrated model to find the optimal T and n. Although the total cost of the integrated model is less than that of Model 1, the cost to the buyer is larger in this model. Model 3 extends Model 2 by applying the variant pricing strategy to the buyer using the coefficient of negotiation, and thus the total cost for the vendor and buyer is less, compared with that in Model 1, while still achieving a win–win objective. Section 4 illustrates the feasibility of the three models by a numerical example. The discussion and conclusions are provided in the last section.

2. Notations and assumptions

For developing the proposed models, the following notations and assumptions are used throughout this paper.

Notations

A	buyer's setup cost per order
S	vendor's setup cost per production run
F	fixed process cost to vendor of dealing with each order
c	buyer's procurement cost per unit item
c_d	buyer's procurement cost per unit when the vendor carries out the pricing strategy, ($c_d = c - \Delta$, $\Delta > 0$)
v	vendor's production cost per unit item
r_b	buyer's holding cost rate per unit per year excluding interest charges
r_v	vendor's holding cost rate per unit per year
p_b	buyer's selling price per unit item ($c < p_b$)
D	annual demand rate of the buyer
P	annual production rate of the vendor ($P > D$)
T_i	replenishment time interval in year unit of the buyer in model i, $i = 1, 2, 3$ (decision variable) $= \begin{cases} T_{i1}, & \text{if } T_i \geqslant M \\ T_{i2}, & \text{if } T_i < M \end{cases}$
M	delay period in payment offered by the vendor
I_d	annual interest rate of deposit for buyer
I_c	annual interest charge to be paid per $ in stock to the bank
I_v	annual interest rate for calculating the vendor's opportunity interest loss due to the delay payment
n_i	frequency of buyer's replenishment during the vendor's production run of each batch in model i, $i = 1, 2, 3$
α	the negotiation coefficient for sharing joint cost savings between vendor and buyer
TB_i	annual total cost for the buyer in model i, $i = 1, 2, 3 = \begin{cases} TB_{i1}, & \text{if } T_i \geqslant M \\ TB_{i2}, & \text{if } T_i < M \end{cases}$
TV_i	annual total cost for the vendor in model i, $i = 1, 2, 3$
TC_i	annual total cost by adding TB_i and TV_i, $i = 1, 2, 3 = \begin{cases} TC_{i1}, & \text{if } T_i \geqslant M \\ TC_{i2}, & \text{if } T_i < M \end{cases}$