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How to make the replenishment and payment strategy under flexible two-part trade credit

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ABSTRACT

In the existing inventory models concerning the two-part trade credit, a common assumption is that the retailer either pays for all the ordered items within a short permissible delay period and receives a cash discount or pays for all the ordered items within a long permissible delay period at the regular price. In this paper, this unrealistic assumption is relaxed. We assume that the retailer may pay any fraction of the purchase cost within the short permissible delay period and receives a cash discount and then the rest is paid within the long permissible delay period. A decision model is proposed for a retailer to determine the optimal ordering policy and payment plan. The closed-form optimal solution to the model is developed and analyzed. Numerical studies show that a retailer can obtain more benefits from the proposed payment plan than from the extreme payment plan in the existing literature.

1. Introduction

In today's global marketplace, trade credit has been widely employed as a facilitated trade tool between vendors and buyers. Trade credit allows a buyer to purchase goods from a vendor without immediate full payment. It is estimated that around 70–80% of trade between firms takes place based on trade credit [33]. Accordingly, most empirical evidence also shows that trade credit is an important source of funds. For example, Peterson and Rajan [24] report that 70% of small firms in the U.S. provide trade credit to its customers. Marotta [19] documents that trade credit finances, on average, 38.1% of the input purchases of non-rationed firms and 37.5% of rationed ones in the Italian manufacturing sector. From the Chinese Academy of Social Sciences' year 2000 survey, Ge and Qiu [9] document that, on average, 27% of the total sales in China is based on trade credit.

Trade credit comes in a wide variety of terms. In practice, however, there are two broad types of agreements: (1) a one-part contract, also known as a net contract, under which a supplier allows a retailer to delay the payment for a fixed period, a 30-day is the most common maturity; (2) a two-part contract, in which a retailer receives a percentage of discount for paying the full purchase cost within a given short period, otherwise the retailer must pay the full purchase cost within the maturity of the contract. For example, under "2/10 net 30", the most common two-part contract in practice, a retailer can receive a 2% discount if the retailer fully pays within 10 days of delivery otherwise pays the full purchase cost between 11 and 30 days [21]. Conventionally, the existing two-part contract is denoted by the form of $(\beta/M_1, n/M_2)$, under which the retailer receives a cash discount of β percentage if all the purchase cost paid within time M_1; otherwise the retailer enjoys the permissible delay in payment up to time M_2 but needs to pay the full purchase cost (i.e., no discount).

As known in the above paragraph, this two-part contract only permits the retailer to use two extreme payment policies, i.e., the retailer has to pay all the purchase cost either at time M_1 or at time M_2. As the market shifting from sellers to buyers, large retailers such as Wal-Mart, Target, and Costco gradually have more market power over their suppliers. This helps retailers have ability to extract favorable contract terms or/and flexible payments, which reduce their overall purchasing cost [18]. In addition, if the retailer has limited capital, the supplier can use the flexible payments to stimulate demand from the retailer and partially accelerate cash flow [8]. These cases motivate us to consider a flexible two-part trade credit contract $(\beta/M_1, n/M_2)$, under which the retailer can pay any λ percent of the total purchase cost within M_1 and enjoy the cash discount of β percentage, and then pay off the remaining balance of $(1-\lambda)$ percent of the total purchase cost by time M_2. The main problem we address is: Given a flexible two-part trade credit policy provided by the supplier, how should the retailer make the replenishment and payment strategy to minimize the total purchasing cost?

In this paper, our main contributions are as follows: First, we propose a decision model for a retailer to determine the optimal replenishment policy and payment plan under a flexible two-part

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trade credit contract. Second, the closed-form optimal solution to the model is developed and analyzed. Finally, our results show that the proposed two-part trade credit model performs better than (at least not worse than) the existing ones in the literature in minimizing the retailer's annual cost.

The remainder of this paper is given as follows: We review the relevant literature in Section 2. Section 3 describes notation and assumptions and develops the model. Section 4 develops some fundamental theoretical results to determine the optimal replenishment cycle time and the payment plan. Section 5 presents numerical examples and sensitivity analysis. Section 6 concludes the paper.

2. Literature review

In the literature, one-part contracts have been investigated by many researchers. For example, Goyal [10] studied the retailer's economic order quantity under the condition of trade credit. After that, many scholars extended Goyal's model from different perspectives. For example, considering a lot-sizing problem for a deteriorating item under trade credit financing, Aggarwal and Jaggi [1] presented a ordering policy based on the convexity of the total cost function. For the same framework, Jamal et al. [17] considered the case with shortages. Chang et al. [3], Chung and Liao [5], and Chung et al. [6] considered deteriorating items with an order-size-dependent trade credit. Recently, Ouyang et al. [22] developed an economic order quantity model for deteriorating items with partially permissible delay in payments depending on the order quantity. The above studies assume that suppliers offer a delayed payment period to retailers, but the retailers do not offer the delayed payment to his customers. Huang [16] proposed an inventory model where not only the supplier offers a credit period to the retailer, but also the retailer offers a credit period to his/her customers. Teng and Goyal [26] addressed the shortcoming of Huang's model and proposed a generalized formulation. Ho [13] proposed a generalized and integrated supplier-retailer inventory model under a two-level trade credit policy. Recently, Zhou et al. [34] further developed a two-echelon uncooperative supply chain model with inventory-dependent demand and limited shelf space, under which a supplier designs trade credit policy to offer incentive for a retailer. Zhou and Zhou [35] showed how a supplier sets an order-quantity-dependent trade credit policy to minimize his/her own annual cost. Many other related articles can be found in Chung and Huang [7], Huang [15], Teng and Chang [27], Min et al. [20], Teng et al. [28], and therein.

A very few have examined the second category of the trade credit agreement. It is well known that a two-part trade credit policy not only stimulates the supplier's demand but also accelerates cash inflow and reduces the default risk. In this category, Huang and Chung [14] developed an inventory model in which the supplier provides a permissible delay and a cash discount for early payment. Ouyang et al. [23] studied an inventory model with non-instantaneous receipt policy, in which the supplier provides both a trade credit financing and a cash discount to the retailer. Teng [25] used the discounted cash flow approach to derive the retailer's optimal ordering polices under a permissible delay in payment and cash discount policy. Recently, Ho et al. [12] discussed the operational impact of a two-part trade credit policy in the integrated inventory model. Chung and Liao [4] further improved Ho et al.'s model by deriving the optimal closed-form formulation for the optimal number of shipments and developing more effective algorithms. Zhong and Zhou [32] studied a two-echelon supply chain with two-part trade credit. Nevertheless, these studies do not address any flexible two-part trade credit policy.

3. Mathematical model

3.1. Notation and assumptions

D Annual demand of the item.

A_r Ordering cost per order.
c_r Unit purchasing cost.
p Unit selling cost.
I_e Interest earned per dollar per year for the retailer.
I_c Interest charges per dollar in stocks per year for the retailer.
s_r The opportunity cost per unit per year, excluding holding cost, which may be measured in practice by $I_c c_r$.
g_r The opportunity gain per unit per year for the retailer, which may be estimated by $I_e p$.
$(\beta/M_1, n/M_2)$ The retailer's trade credit scenario offered by the supplier (assume, $0 < M_1 < M_2$). It can be interpreted as follows: The supplier offers a β discount if the payment is made by time M_1, otherwise the full purchase cost of the merchandise (i.e., n represents 'no discount') is due at time M_2.
λ The fraction of the purchase cost that the retailer pays to the supplier at the time M_1. (Decision variable).
$1-\lambda$ The portion of the purchase cost that the retailer pays to the supplier at the time M_2.
T Inventory cycle length. (Decision variable).
$TC_r(T, \lambda)$ The retailer's annual cost function.

(1) The lead time is negligible.
(2) Shortages are not allowed.
(3) The retailer can accumulate revenue and earn interest from the beginning of the inventory cycle until the end of the trade credit period offered by the supplier. That is, the retailer can accumulate revenue and earn interest during the period from $t=0$ to $t=M_2$ with rate I_e.
(4) The retailer's opportunity cost per unit s_r is always no less than his/her opportunity gain per unit g_r, which is mainly to avoid the incentive that lets the retailer keep the accumulated revenue all the time to get profits. This assumption is used directly or implicitly by many researchers like Goyal [10], Huang and Chung [14], etc.

3.2. Modeling

The annual total relevant cost consists of the following elements.

(1) Annual ordering cost $=A_r/T$.
(2) Annual stock holding cost (excluding interest charges) $=DTh_r/2$.
(3) Discount revenue $=\beta\lambda c_r D$
(4) The opportunity cost and/or interest earned per year.

Based on the values of T, M_1 and M_2, one has the three cases: (i) $T \le M_1$; (ii) $M_1 < T \le M_2$; and (iii) $T > M_2$, respectively. According to assumptions (3) and (4), we derive the retailer's opportunity cost and/or interest earned per year as follows:

Case 1. $T \le M_1$, shown in Fig. 1.

The retailer sells all items and receives all sales revenue before paying the purchase cost to the supplier. Therefore, in this case, there is no opportunity cost. On the other hand, the retailer earns interest on average sales revenue during the interval $[0, T]$, on full sales revenue during the interval $[T, M_1]$, and on $(1-\lambda)$ fraction of full sales revenue during the interval $[M_1, M_2]$. Hence the total interest earned per year is $g_r D(M_1 - T/2) + (1-\lambda) g_r D(M_2 - M_1)$.