An EOQ Model under Retailer Partial Trade Credit in Two-echelon Supply Chain

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Abstract

In this paper, we want to investigate the retailer’s inventory policy when the retailer maintains a powerful position in two-echelon supply chain. That is, we assumed that the retailer can obtain the full trade credit offered by the supplier yet the retailer just offers the partial trade credit to his/her customers under two-level trade credit situation. Then, we investigate the retailer’s inventory system as a cost minimization problem to determine the retailer’s optimal inventory policy in two-echelon supply chain. Finally, numerical examples are given to illustrate the results and to obtain managerial insights.

Keywords: Inventory, EOQ, Two-level trade credit, Two-echelon supply chain
1. Introduction

In classical economic order quantity (EOQ) model assumes that the retailer must pay for the items as soon as the items are received. However, this may not be true. In practice, the supplier will offer the retailer a delay period, that is the trade credit period, in paying for the amount of purchase. Before the end of the trade credit period, the retailer can sell the goods and accumulate revenue and earn interest. A higher interest is charged if the payment is not settled by the end of the trade credit period. In the real world, the supplier often makes use of this policy to promote his/her commodities.

Goyal [3] established a single-item inventory model under trade credit. Khouja and Mehrez [11] investigated the effect of four different supplier credit policies on the optimal order quantity within the EOQ framework. Chung [1] developed an efficient decision procedure to determine the economic order quantity under condition of permissible delay in payments. Teng [12] assumed that the selling price was not equal to the purchasing price to modify Goyal’s model [3]. Chung and Huang [2] investigated this issue within EPQ (economic production quantity) framework and developed an efficient solving procedure to determine the optimal replenishment cycle for the retailer. Huang and Chung [8] investigated the inventory policy under cash discount and trade credit. Huang [5] adopted alternative payment rules, and, assumed finite replenishment rate, to investigate the buyer’s inventory problem. Huang [6] extended Huang [4] to develop retailer’s inventory policy under two-level trade credit policy and retailer’s storage space limited. Recently, Huang et al. [9] developed retailer’s replenishment policy under partially trade credit policy and retailer’s storage space limited. Huang [7] incorporated Chung and Huang [2] and Huang [4] to investigate retailer’s ordering policy. Recently, Huang et al. [10] developed the retailer’s ordering decision-making under two-level trade credit policy when the retailer with a powerful position.
Most of all above articles implicitly assumed that the customer would pay for the items as soon as the items are received from the retailer. That is, they assumed that the supplier would offer the retailer a delay period but the retailer would not offer a trade credit period to his/her customers. That is one-level trade credit. Recently, Huang [4] modified this assumption to assume that the retailer will adopt a similar trade credit policy to stimulate demand from his/her customer to develop the retailer’s replenishment model. That is two-level trade credit.

In the present study, the authors wish to extend Huang’s model [4] to investigate the situation in which the retailer has a powerful position in the two-echelon supply chain. That is, we assume that the retailer can obtain the full trade credit offered by the supplier and the retailer just offers the partial trade credit to his/her customer. In practice, this model setting is more realistic. For example, the Toyota Company can ask his supplier to offer him the full trade credit and can just offer partial trade credit to his dealer. That is, the Toyota Company can delay its paying full amount of purchasing until the end of delay period offered by his supplier. But the Toyota Company offers only partial delay payment to his dealer within the permissible credit period and the rest of the total amount is payable at the time the dealer places a replenishment order. In addition, we want to relax the unrealistic assumption of unit purchasing cost and unit selling price are equal in Huang [4]. Under these conditions, we remodel the retailer’s inventory model as a cost minimization problem to determine the retailer’s optimal ordering policies.

2. Model formulation

Notation:

\[D = \text{demand rate per year;}

\[A = \text{ordering cost per order;}

c = unit purchasing price;

s = unit selling price;

h = unit stock holding cost per year excluding interest charges;

α = the customer’s fraction of the total amount payable at the time of placing an order within the delay period to the retailer, 0 ≤ α ≤ 1;

I_e = interest earned per $ per year;

I_k = interest charged per $ in stocks per year by the supplier;

M = the retailer’s trade credit period as measured by years offered by the supplier;

N = the customer’s trade credit period as measured by years offered by the retailer;

T = the cycle time in years;

TRC(T)= the annual total relevant cost, which is a function of T;

T* = the optimal cycle time of TRC(T);

Q* = the optimal order quantity, also defined by DT*.

Assumptions:

(1) Demand rate, D, is known and constant.

(2) Shortages are not allowed.

(3) Time horizon is infinite.

(4) Replenishments are instantaneous.

(5) I_k ≥ I_e, M ≥ N.

(6) Since the supplier offers the full trade credit to the retailer. When T ≥ M, the account is settled at T=M the retailer pays off all units sold and keeps his/her profits, and starts paying for the interest charges on the items in stock with rate I_k. When T ≤ M, the account is settled at T=M and the retailer does not need to pay any interest charge.

(7) Since the retailer just offers the partial trade credit to his/her customers. Hence, his/her
customers must make a partial payment to the retailer when the item is received. Then his/her customers must pay off the remaining balance at the end of the trade credit period offered by the retailer. That is, the retailer can accumulate interest from his/her customer partial payment on \((0, N]\) and from the total amount of payment on \([N, M]\) with rate \(I_c\).

The annual total relevant cost consists of the following elements.

(1) Annual ordering cost = \(\frac{A}{T}\).

(2) Annual stock holding cost (excluding interest charges) = \(\frac{DTh}{2}\).

(3) According to assumption (6), there are three cases to consider in costs of interest charges for the items kept in stock per year.

Case 1: \(M \leq T\).

Annual interest payable = \(cI_s D(T - M)^2 / 2T\).

Case 2: \(N \leq T \leq M\).

In this case, annual interest payable = 0.

Case 3: \(T \leq N\).

Similar to Case 2, annual interest payable = 0.

(4) According to assumption (7), there are three cases to consider in interest earned per year.

Case 1: \(M \leq T\), as shown in Figure 1.

Annual interest earned =

\[
sl_x\left[\frac{\alpha DN^2}{2} + \frac{(DN + DM)(M - N)}{2}\right]/T = sl_x D[M^2 - (1 - \alpha)N^2]/2T.
\]

Case 2: \(N \leq T \leq M\), as shown in Figure 2.
Annual interest earned =

\[ sI_e \left( \frac{\alpha DN^2}{2} + (DN + DT)(T - N) + DT(M - T) \right)/T = sI_e D[2MT - (1 - \alpha)N^2 - T^2]/2T. \]

Case 3: \( T \leq N \), as shown in Figure 3.

Annual interest earned

\[ = sI_e \left( \frac{\alpha DT^2}{2} + aDT(N - T) + DT(M - N) \right)/T = sI_e DT[M - (1 - \alpha)N - \frac{\alpha T}{2}]/T. \]

From the above arguments, the annual total relevant cost for the retailer can be expressed as

\[ TRC(T) = \text{ordering cost} + \text{stock-holding cost} + \text{interest payable} - \text{interest earned}. \]

\[ TRC(T) = \begin{cases} 
TRC_1(T) & \text{if } T \geq M \\
TRC_2(T) & \text{if } N \leq T \leq M \\
TRC_3(T) & \text{if } 0 < T \leq N 
\end{cases} \]

where

\[ TRC_1(T) = \frac{A}{T} + \frac{DTh}{2} + cI_e D(T - M)^2/2T - sI_e D[M^2 - (1 - \alpha)N^2]/2T, \] (2)

\[ TRC_2(T) = \frac{A}{T} + \frac{DTh}{2} - sI_e D[2MT - (1 - \alpha)N^2 - T^2]/2T \] (3)

and

\[ TRC_3(T) = \frac{A}{T} + \frac{DTh}{2} - sI_e D[M - (1 - \alpha)N - \frac{\alpha T}{2}]. \] (4)

Since \( TRC_1(M) = TRC_2(M) \) and \( TRC_2(N) = TRC_3(N) \), \( TRC(T) \) is continuous and well-defined. All \( TRC_1(T), TRC_2(T), TRC_3(T) \) and \( TRC(T) \) are defined on \( T > 0 \). Equations (2), (3) and (4) yield
\begin{align*}
TRC_1'(T) &= \left[\frac{2A + DM^2(cI_k - sI_c) + sD(1-\alpha)N^2I_c}{2T^2}\right] + D\left(\frac{h + cI_k}{2}\right), \quad (5) \\
TRC_1''(T) &= \frac{2A + D[M^2(cI_k - sI_c) + s(1-\alpha)N^2I_c]}{T^3}, \quad (6) \\
TRC_2'(T) &= \left[\frac{2A + sD(1-\alpha)N^2I_c}{2T^2}\right] + D\left(\frac{h + sI_c}{2}\right), \quad (7) \\
TRC_2''(T) &= \frac{2A + sD(1-\alpha)N^2I_c}{T^3} > 0, \quad (8)
\end{align*}

and

\begin{align*}
TRC_3'(T) &= \frac{-A}{T^2} + D\left(\frac{h + s\alpha I_c}{2}\right) \quad (9) \\
TRC_3''(T) &= \frac{2A}{T^3} > 0. \quad (10)
\end{align*}

Equations (8) and (10) imply that \( TRC_2(T) \) and \( TRC_3(T) \) are convex on \( T > 0 \). However, \( TRC_1(T) \) is convex on \( T > 0 \) if \( \beta > 0 \). Where \( \beta = 2A + D[M^2(cI_k - sI_c) + s(1-\alpha)N^2I_c] \).

Furthermore, we have \( TRC_1'(M) = TRC_2'(M) \) and \( TRC_2'(N) = TRC_3'(N) \). Therefore, equations 1(a, b, c) imply that \( TRC(T) \) is convex on \( T > 0 \) if \( \beta > 0 \). Then, we have the following results.

**Theorem 1:**

(A). If \( \beta \leq 0 \), then \( TRC(T) \) is convex on \( (0, M) \) and concave on \( [M, \infty) \).

(B). If \( \beta > 0 \), then \( TRC(T) \) is convex on \( (0, \infty) \).

### 3. Determination of the optimal cycle time \( T^* \)

Let \( TRC_i'(T_i^*) = 0 \) for all \( i = 1, 2, 3 \). We can obtain

\[ T_i^* = \sqrt[3]{\frac{2A + D[M^2(cI_k - sI_c) + s(1-\alpha)N^2I_c]}{D(h + cI_k)}}, \quad (11) \]
\[ T_2^* = \sqrt{\frac{2A + sD(1 - \alpha)N^2 I_e}{D(h + sI_e)}} \]  
\[ T_3^* = \sqrt{\frac{2A}{D(h + s\alpha I_e)}}. \]

By the convexity of \( TRC_i(T) \) (i = 1, 2, 3), we have

\[
\begin{align*}
TRC_i'(T) &= \begin{cases} < 0 & \text{if } T < T_i^* \\ = 0 & \text{if } T = T_i^* \\ > 0 & \text{if } T > T_i^*. \end{cases} (14a) \\
TRC_i'(T) &= \begin{cases} < 0 & \text{if } T < T_i^* \\ = 0 & \text{if } T = T_i^* \\ > 0 & \text{if } T > T_i^*. \end{cases} (14b) \\
TRC_i'(T) &= \begin{cases} < 0 & \text{if } T < T_i^* \\ = 0 & \text{if } T = T_i^* \\ > 0 & \text{if } T > T_i^*. \end{cases} (14c)
\end{align*}
\]

Equations (5), (7) and (9) yield that

\[ TRC_1'(M) = TRC_2'(M) = \frac{-2A + DM^2(h + sI_e) - sD(1 - \alpha)N^2 I_e}{2M^2} \]  
\[ TRC_2'(N) = TRC_3'(N) = \frac{-2A + DN^2(h + s\alpha I_e)}{2N^2}. \]

Furthermore, we let

\[ \Delta_1 = -2A + DM^2(h + sI_e) - sD(1 - \alpha)N^2 I_e \]

and

\[ \Delta_2 = -2A + DN^2(h + s\alpha I_e). \]

Then, we see \( \Delta_1 \geq \Delta_2 \).

3.1 **Suppose that** \( \beta \leq 0 \)

When \( \beta \leq 0 \), we can find \( TRC_1(T) \) is increasing on \([M, \infty)\) from equation (9) and \( \Delta_1 > 0 \) from equation (17). By the convexity of \( TRC_i(T) \) (i = 2, 3), we see

\[
\begin{align*}
TRC_i'(T) &= \begin{cases} < 0 & \text{if } T < T_i^* \\ = 0 & \text{if } T = T_i^* \\ > 0 & \text{if } T > T_i^*. \end{cases} (19a) \\
TRC_i'(T) &= \begin{cases} < 0 & \text{if } T < T_i^* \\ = 0 & \text{if } T = T_i^* \\ > 0 & \text{if } T > T_i^*. \end{cases} (19b) \\
TRC_i'(T) &= \begin{cases} < 0 & \text{if } T < T_i^* \\ = 0 & \text{if } T = T_i^* \\ > 0 & \text{if } T > T_i^*. \end{cases} (19c)
\end{align*}
\]
Then, we have the following result to determine the optimal cycle time $T^*$.

**Theorem 2**: Suppose that $\beta \leq 0$. Then,

(A) If $\Delta_2 \geq 0$, then $TRC(T^*) = TRC(T_3^*)$ and $T^* = T_3^*$.

(B) If $\Delta_2 < 0$, then $TRC(T^*) = TRC(T_2^*)$ and $T^* = T_2^*$.

**Proof:**

(A) If $\Delta_2 \geq 0$, then $TRC_1'(M) = TRC_2'(M) > 0$ and $TRC_2'(N) = TRC_3'(N) \geq 0$.

Equations 19(a, b, c) imply that

(i) $TRC_1(T)$ is increasing on $[M, \infty)$.

(ii) $TRC_2(T)$ is increasing on $[N, M]$.

(iii) $TRC_3(T)$ is decreasing on $(0, T_3^*)$ and increasing on $[T_3^*, N]$.

Combining (i), (ii), (iii) and equations 1(a, b, c), we have that $TRC(T)$ is decreasing on $(0, T_3^*)$ and increasing on $[T_3^*, \infty)$. Consequently, $T^* = T_3^*$.

(B) If $\Delta_2 < 0$, then $TRC_1'(M) = TRC_2'(M) > 0$ and $TRC_2'(N) = TRC_3'(N) < 0$.

Equations 19(a, b, c) imply that

(i) $TRC_1(T)$ is increasing on $[M, \infty)$.

(ii) $TRC_2(T)$ is decreasing on $[N, T_2^*)$ and increasing on $[T_2^*, M]$.

(iii) $TRC_3(T)$ is decreasing on $(0, N]$.

Combining (i), (ii), (iii) and equations 1(a, b, c), we have that $TRC(T)$ is decreasing on $(0, T_2^*)$ and increasing on $[T_2^*, \infty)$. Consequently, $T^* = T_2^*$.

Linking together the above arguments, we have completed the proof of Theorem 2.

Theorem 2 immediately determines the optimal cycle time $T^*$ after computing for the number $\Delta_2$ when $\beta \leq 0$. Theorem 2 is an efficient solution procedure.

### 3.2 Suppose that $\beta > 0$
When $\beta > 0$, all $T_i^* (i=1, 2, 3)$ are well-defined. By the convexity of $TRC_i(T)$ ($i = 1, 2, 3$), we see

$$TRC_i'(T) = \begin{cases} < 0 & \text{if } T < T_i^* \\ 0 & \text{if } T = T_i^* \\ > 0 & \text{if } T > T_i^*. \end{cases} \quad (20a)$$

$$TRC_i'(T) = \begin{cases} > 0 & \text{if } T < T_i^* \\ 0 & \text{if } T = T_i^* \\ < 0 & \text{if } T > T_i^*. \end{cases} \quad (20b)$$

Then, we have the following results to determine the optimal cycle time $T^*$.

**Theorem 3**: Suppose that $\beta > 0$. Then,

(A) If $\Delta_1 > 0$ and $\Delta_2 \geq 0$, then $TRC(T^*) = TRC(T_3^*)$ and $T^* = T_3^*$.

(B) If $\Delta_1 > 0$ and $\Delta_2 < 0$, then $TRC(T^*) = TRC(T_2^*)$ and $T^* = T_2^*$.

(C) If $\Delta_1 \leq 0$ and $\Delta_2 < 0$, then $TRC(T^*) = TRC(T_1^*)$ and $T^* = T_1^*$.

**Proof**:

(C) If $\Delta_1 > 0$ and $\Delta_2 \geq 0$, then $TRC_1'(M) = TRC_2'(M) > 0$ and

$$TRC_2(N) = TRC_3'(N) \geq 0.$$ Equations 20(a, b, c) imply that

(iv) $TRC_1(T)$ is increasing on $[M, \infty)$.

(v) $TRC_2(T)$ is increasing on $[N, M]$.

(vi) $TRC_3(T)$ is decreasing on $(0, T_3^*)$ and increasing on $[T_3^*, N]$.

Combining (i), (ii), (iii) and equations 1(a, b, c), we have that $TRC(T)$ is decreasing on $(0, T_3^*)$ and increasing on $[T_3^*, \infty)$. Consequently, $T^* = T_3^*$.

(D) If $\Delta_1 > 0$ and $\Delta_2 < 0$, then $TRC_1'(M) = TRC_2'(M) > 0$ and

$$TRC_2(N) = TRC_3'(N) < 0.$$ Equations 20(a, b, c) imply that

(i) $TRC_1(T)$ is increasing on $[M, \infty)$.

(ii) $TRC_2(T)$ is decreasing on $[N, T_2^*]$ and increasing on $[T_2^*, M]$.

(iii) $TRC_3(T)$ is decreasing on $(0, N]$.

Combining (i), (ii), (iii) and equations 1(a, b, c), we have that $TRC(T)$ is
decreasing on  \((0, T_2^*]\) and increasing on \([T_2^*, \infty)\). Consequently, \(T^* = T_2^*\).

(E) If \(\Delta_1 \leq 0\) and \(\Delta_2 < 0\), then \(TRC_1'(M) = TRC_2'(M) \leq 0\) and

\[ TRC_2'(N) = TRC_3'(N) < 0. \]

Equations 20(a, b, c) imply that

(i) \(TRC_1(T)\) is decreasing on \([M, T_1^*]\) and increasing on \([T_1^*, \infty)\).

(ii) \(TRC_2(T)\) is decreasing on \([N, M]\).

(iii) \(TRC_3(T)\) is decreasing on \((0, N]\).

Combining (i), (ii), (iii) and equations 1(a, b, c), we have that \(TRC(T)\) is decreasing on \((0, T_1^*]\) and increasing on \([T_1^*, \infty)\). Consequently, \(T^* = T_1^*\).

Linking together the above arguments, we have completed the proof of Theorem 3. Theorem 3 immediately determines the optimal cycle time \(T^*\) after computing for the numbers \(\Delta_1\) and \(\Delta_2\). Theorem 3 is an efficient solution procedure.

4. Numerical examples

To illustrate the results developed in this paper, let us apply the proposed method to solve the following numerical examples. For convenience, the numerical values of the parameters are selected randomly. The optimal solutions for different parameters of \(\alpha, N\) and \(s\) are shown in Table 1. Based on the results as shown in Table 1, the following inferences can be made:

(1). For fixed \(N\) and \(s\), the larger value of \(\alpha\) is, the shorter the optimal cycle time and the lower the annual total relevant cost.

(2). For fixed \(\alpha\) and \(s\), the larger the value of \(N\) is, the lengthier the optimal cycle time and the higher the annual total relevant cost.

(3). For fixed \(\alpha\) and \(N\), the larger the value of \(s\) is, the shorter the optimal cycle time and the lower the annual total relevant cost.
5. Conclusions

This paper further relaxes the assumption of the two-level trade credit policy in the previously published works to investigate the inventory problem in which the retailer maintains a powerful position. Theorem 2 and Theorem 3 help the retailer accurately and speedily determining the optimal ordering policy after computing for the numbers $\Delta_1$ and $\Delta_2$. Finally, numerical examples are given to illustrate the results developed in this paper.

There are several managerial insights as follows:

(1). When the customer’s fraction of the total amount due at the time of placing an order to the retailer is increasing, the retailer will order a smaller quantity and increase its order frequency. The retailer can save a larger amount of interest earned under higher order frequency and receiving a larger customer’s fraction of the total amount due at the time of placing an order within the delay period offered by retailer.

(2). When a longer trade credit period offered to his/her customer, the retailer will order a larger quantity to save interest payments paid to the suppliers to compensate the loss of interest earned paid by his/her customers.

(3). When the unit selling price is increasing, the retailer will order a smaller quantity to enjoy the benefits of the trade credit more frequently.
Table 1. Optimal solutions under various parametric values

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>$N$</th>
<th>$s$</th>
<th>$\beta$</th>
<th>$\Delta_1$</th>
<th>$\Delta_2$</th>
<th>Theorem</th>
<th>$T^*$</th>
<th>$Q^*$</th>
<th>TRC($T^*$)</th>
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<tr>
<td>0.1</td>
<td>0.02</td>
<td>10</td>
<td>&gt; 0</td>
<td>&gt; 0</td>
<td>&lt; 0</td>
<td>3-(C)</td>
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<td>671.63</td>
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<td></td>
<td>30</td>
<td>&gt; 0</td>
<td>&gt; 0</td>
<td>&lt; 0</td>
<td>3-(B)</td>
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<td>172.6</td>
<td>411.11</td>
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<td>&lt; 0</td>
<td>&gt; 0</td>
<td>&lt; 0</td>
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Acknowledgements

This paper is supported by NSC Taiwan, no. NSC 96-2221-E-324-007-MY3.
References


5. Huang, Y.F. Optimal retailer’s replenishment policy for the EPQ model under supplier’s trade credit policy, Production Planning & Control, 15, 27-33, 2004.

6. Huang, Y.F. An inventory model under two levels of trade credit and limited storage space derived without derivatives, Applied Mathematical Modelling, 30, 418-436, 2006.


Figure 1. The total amount of interest earned when $M \leq T$
Figure 2. The total amount of interest earned when $N \leq T \leq M$
Figure 3. The total amount of interest earned when $T \leq N$