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Economic order quantity under retailer partial trade credit in two-echelon supply chain

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SUMMARY

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 their 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.

***Key words**: 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 [1] derived a mathematical model, when the supplier offers credit period in settling the account to the retailer. Chung [2] developed an alternative approach to determine the economic order quantity under trade credit. Aggarwal and Jaggi [3] considered the inventory model with an exponential deterioration rate under trade credit. Chang et al. [4] extended this line of research to the varying rate of deterioration. Liao et al. [5] and Sarker et al. [6] investigated this topic with inflation. Jamal et al. [7] and Chang and Dye [8] extended this line of research with allowable shortage. Chang et al. [9] extended this line of research with linear demand. Chen and Chuang [10] investigated buyer's inventory policy under trade credit by the concept of discounted cash flow. Hwang and Shinn [11] modeled an inventory system for retailer's pricing and lot sizing policy for exponentially deteriorating products under the condition of permissible delay in payment. Jamal et al. [12] and Sarker et al. [13] developed retailer's policy for optimum cycle and payment times for a retailer in deteriorating item inventory scenario where a supplier allows a specified credit period to the retailer for payment without penalty. Teng [14] assumed that the selling price is not equal to the purchasing price to modify the Goyal's model [1]. Chung et al. [15] discussed this issue under the assumptions that the selling price is not equal to the purchasing price and different payment rules are allowed. Shinn and Hwang [16] determined the retailer's optimal price and order size simultaneously under the condition of order-size-dependent delay in payments. They assumed that the length of the credit period is a function of the retailer's order size, and also the demand rate is a function of the selling price. Chung and Huang [17] extended this type of problem-solving within the EPQ framework and developed an efficient procedure to determine the retailer's optimal ordering policy. Huang and Chung [18] extended Goyal's model [1] to allow for cash discount for early payment. Salameh et al. [19] extended this issue to inventory decision under continuous review. Chang et al. [20] and Chung and Liao [21] deal with the problem of determining the economic order quantity for exponentially deteriorating items under permissible delay in payments depending on the ordering quantity. Chang [22] extended this issue to inflation and finite time horizon. Huang [23] considered the case in which the unit selling price and the unit purchasing price are not necessarily equal within the EPQ framework under supplier's trade credit policy.

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 [24] 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. This new viewpoint matches the real-life situations in the two-echelon supply chain. Recently, Huang [25] extended Huang [24] to develop retailer's inventory policy under retailer's storage space limited. Huang [26] incorporated Chung and Huang [17] and Huang [24] to investigate retailer's ordering policy.

In the present study, the authors wish to extend Huang's model [24] 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 which are equal in Huang [24]. 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 = demand rate per year;
- A = 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, $0 \le \alpha \le 1$;
- 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) $I_k \ge I_e$, $M \ge N$.

(6) Since the supplier offers the full trade credit to the retailer. When $T \ge M$, 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 $T \le$ 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_e.

The annual total relevant cost consists of the following elements:

(1) Annual ordering cost = A / T.

(2) Annual stock holding cost (excluding interest charges) = $DTh / 2$.

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

<u>Case 1</u>: $M \le T$.

Annual interest payable = $cI_k D(T-M)^2 / 2T$

<u>Case 2</u>: $N \le T \le M$.

In this case, annual interest payable = 0.

<u>Case 3</u>: $T \le N$.

Similar to Case 2, annual interest payable = 0.

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

<u>Case 1</u>: $M \le T$, as shown in Figure 1.

Annual interest earned =

$$sI_e\left[\frac{\alpha DN^2}{2}+\frac{(DN+DM)(M-N)}{2}\right]\Big/T = sI_eD\left[M^2-(1-\alpha)N^2\right]\Big/2T$$

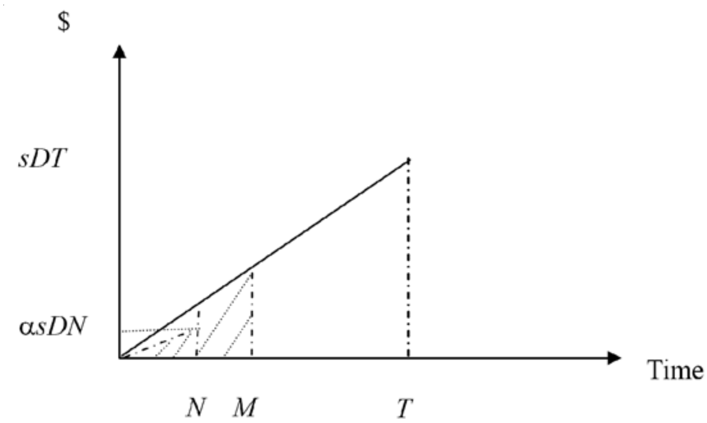


Fig. 1 The total amount of interest earned when $M \le T$

<u>Case 2</u>: $N \le T \le M$, as shown in Figure 2.

Annual interest earned =

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

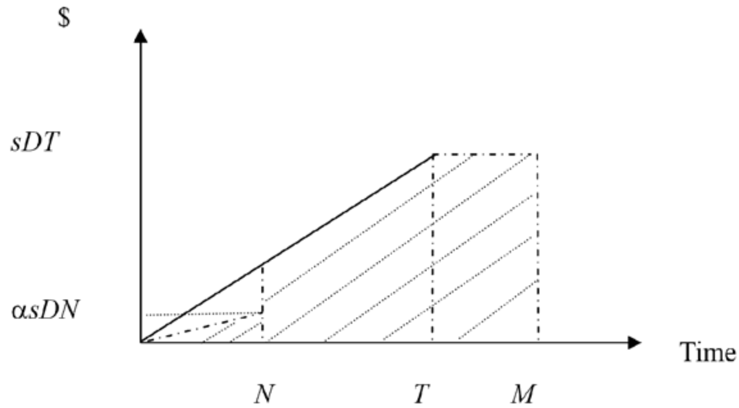


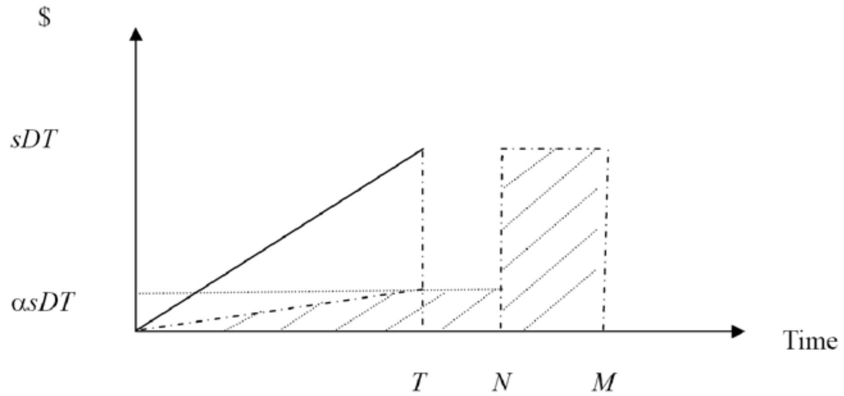
Fig. 2 The total amount of interest earned when $N \le T \le M$

<u>Case 3</u>: $T \le N$, as shown in Figure 3.

Annual interest earned =

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

Fig. 3 The total amount of interest earned when $T \le N$



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

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

$$TRC\left(T\right)=\begin{cases}TRC_1\left(T\right) & \text{if} \quad T\ge M & (a)\\ TRC_2\left(T\right) & \text{if} \quad N\le T\le M & (b)\\ TRC3\left(T\right) & \text{if} \quad 0<T\le M & (c)\end{cases} \tag{1}$$

where:

$$TRC_1\left(T\right)=\frac{A}{T}+\frac{DTh}{2}+cI_kD\left(T-M\right)^2\Big/2T-s\,I_eD\left[M^2-\left(1-\alpha\right)N^2\right]\Big/2T \tag{2}$$

$$TRC_2\left(T\right)=\frac{A}{T}+\frac{DTh}{2}-s\,I_eD\left[2MT-\left(1-\alpha\right)N^2-T^2\right]\Big/2T \tag{3}$$

and:

$$TRC_3\left(T\right)=\frac{A}{T}+\frac{DTh}{2}-sI_eD\left[M-\left(1-\alpha\right)N-\frac{\alpha T}{2}\right] \tag{4}$$

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:

$$TRC_1{}'\left(T\right)=-\left[\frac{2A+DM^2\left(cI_k-sI_e\right)+sD\left(1-\alpha\right)N^2I_e}{2T^2}\right]+D\left(\frac{h+cI_k}{2}\right) \tag{5}$$

$$TRC_1{}''\left(T\right)=\frac{2A+D\left[M^2\left(cI_k-sI_e\right)+s\left(1-\alpha\right)N^2I_e\right]}{T^3} \tag{6}$$

$$TRC_2{}'\left(T\right)=-\left[\frac{2A+sD\left(1-\alpha\right)N^2I_e}{2T^2}\right]+D\left(\frac{h+sI_e}{2}\right) \tag{7}$$

$$TRC_2{}''\left(T\right)=\frac{2A+sD\left(1-\alpha\right)N^2I_e}{T^3}>0 \tag{8}$$

and:

$$TRC_3'(T) = -\frac{A}{T^2} + D\left(\frac{h+s\alpha I_e}{2}\right) \tag{9}$$

$$TRC_3''(T) = \frac{2A}{T^3} > 0 \tag{10}$$

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:

$$\beta = 2A + D\left[M^2\left(cI_k - sI_e\right) + s(1-\alpha)N^2 I_e\right].$$

Furthermore, we have $TRC_1'(M)=TRC_2'(M)$ and $TRC_2'(N)=TRC_3'(N)$. Therefore, Eqs. 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 $\beta \le 0$, 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 $TRC_i'(T^*)=0$ for all $i=1,2,3$. We can obtain:

$$T_1^* = \sqrt{\frac{2A + D\left[M^2\left(cI_k - sI_e\right) + s(1-\alpha)N^2 I_e\right]}{D\left(h + cI_k\right)}} \tag{11}$$

$$T_2^* = \sqrt{\frac{2A + sD(1-\alpha)N^2 I_e}{D\left(h + sI_e\right)}} \tag{12}$$

and:

$$T_3^* = \sqrt{\frac{2A}{D\left(h + s\alpha I_e\right)}} \tag{13}$$

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

$$TRC_i'(T)\begin{cases} <0 & if \quad T < T_i^* & (a) \\ =0 & if \quad T = T_i^* & (b) \\ >0 & if \quad T > T_i^* & (c) \end{cases} \tag{14}$$

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

$$TRC_1'(M) = TRC_2'(M) = \\ = \frac{-2A + DM^2\left(h + sI_e\right) - sD(1-\alpha)N^2 I_e}{2M^2} \tag{15}$$

and:

$$TRC_2'(N) = TRC_3'(N) = \frac{-2A + DN^2\left(h + s\alpha I_e\right)}{2N^2} \tag{16}$$

Furthermore, we let:

$$\Delta_1 = -2A + DM^2\left(h + sI_e\right) - sD(1-\alpha)N^2 I_e \tag{17}$$

$$\Delta_2 = -2A + DN^2\left(h + s\alpha I_e\right) \tag{18}$$

Then, we see $\Delta_1 \ge \Delta_2$.

3.1 Suppose that $\beta \le 0$

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

$$TRC_i'(T)\begin{cases} <0 & if \quad T < T_i^* & (a) \\ =0 & if \quad T = T_i^* & (b) \\ >0 & if \quad T > T_i^* & (c) \end{cases} \tag{19}$$

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

Theorem 2: Suppose that $\beta \le 0$. Then:

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

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 Eqs. 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 Eqs. 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 Δ_2 when $\beta \le 0$. 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:

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

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:

(A) 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:

(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 $[T3^*, N]$.

Combining (i), (ii), (iii) and Eqs. 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 $\Delta_1 > 0$ 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 Eqs. 1(a, b, c), we have that $TRC(T)$ is decreasing on $(0, T_2^*]$ and increasing on $[T_2^*, \infty)$. Consequently, $T^*=T_2^*$.

(C) 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 Eqs. 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 Δ_1 and Δ_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 α, 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 α is, the shorter the optimal cycle time and the lower the annual total relevant cost;

(2) For fixed α and s, the larger the value of N is, the longer the optimal cycle time and the higher the annual total relevant cost;

(3) For fixed α 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 Δ_1 and Δ_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 frenquency 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

Let : A = \$50/order, D = 2000 units/year, c = \$8/unit, h = \$3/unit/year, I_k = \$0.15/\$/year, I_e = \$0.13/\$/year and M = 0.1 year.									
α	N	s	β	Δ_1	Δ_2	Theorem	T^*	Q^*	$TRC(T^*)$
0.1	0.02	10	> 0	> 0	< 0	3-(C)	T_2^*=0.10853	217.1	671.63
		30	> 0	> 0	< 0	3-(B)	T_2^*=0.08631	172.6	411.11
		50	< 0	> 0	< 0	2-(B)	T_2^*=0.07423	148.5	110.29
	0.05	10	> 0	> 0	< 0	3-(C)	T_1^*=0.11119	222.4	693.99
		30	> 0	> 0	< 0	3-(B)	T_2^*=0.09229	184.6	493.65
		50	> 0	> 0	< 0	3-(B)	T_2^*=0.08248	165.0	267.08
	0.08	10	> 0	< 0	< 0	3-(C)	T_1^*=0.11597	231.9	734.17
		30	> 0	> 0	< 0	3-(C)	T_1^*=0.10404	208.1	633.95
		50	> 0	> 0	< 0	3-(B)	T_2^*=0.09594	191.9	522.83
0.5	0.02	10	> 0	> 0	< 0	3-(C)	T_1^*=0.10830	216.6	669.71
		30	> 0	> 0	< 0	3-(B)	T_2^*=0.08579	171.6	403.86
		50	< 0	> 0	< 0	2-(B)	T_2^*=0.07348	147.0	92.21
	0.05	10	> 0	> 0	< 0	3-(C)	T_1^*=0.10979	219.6	682.23
		30	> 0	> 0	< 0	3-(B)	T_2^*=0.08918	178.4	450.67
		50	> 0	> 0	< 0	3-(B)	T_2^*=0.07822	156.4	186.19
	0.08	10	> 0	< 0	< 0	3-(C)	T_1^*=0.11250	225.0	705.03
		30	> 0	> 0	< 0	3-(B)	T_2^*=0.09516	190.3	533.18
		50	> 0	> 0	< 0	3-(B)	T_2^*=0.08633	172.7	340.24
0.9	0.02	10	> 0	> 0	< 0	3-(C)	T_1^*=0.10807	216.1	667.79
		30	> 0	> 0	< 0	3-(B)	T_2^*=0.08526	170.5	396.57
		50	< 0	> 0	< 0	2-(B)	T_2^*=0.07274	145.5	81.98
	0.05	10	> 0	> 0	< 0	3-(C)	T_1^*=0.10837	216.7	670.31
		30	> 0	> 0	< 0	3-(B)	T_2^*=0.08595	171.9	406.13
		50	< 0	> 0	< 0	2-(B)	T_2^*=0.07372	147.4	100.62
	0.08	10	> 0	> 0	< 0	3-(C)	T_1^*=0.10893	217.9	674.97
		30	> 0	> 0	< 0	3-(B)	T_2^*=0.08722	174.4	423.70
		50	> 0	> 0	> 0	3-(A)	T_3^*=0.07516	150.3	134.41

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6. REFERENCES

[1] S.K. Goyal, Economic order quantity under conditions of permissible delay in payments, *J. Opl. Res. Soc.*, Vol. 36, pp. 335-338, 1985.

[2] K.J. Chung, A theorem on the determination of economic order quantity under conditions of permissible delay in payments, *Comp. Opns. Res.*, Vol. 25, pp. 49-52, 1998.

[3] S.P. Aggarwal and C.K. Jaggi, Ordering policies of deteriorating items under permissible delay in payments, *J. Opl. Res. Soc.*, Vol. 46, pp. 658-662, 1995.

[4] H.J. Chang, C.H. Hung and C.Y. Dye, A finite time horizon inventory model with deterioration and time-value of money under the conditions of permissible delay in payments, *Int. J. Syst. Sci.*, Vol. 33, pp. 141-151, 2002.

[5] H.C. Liao, C.H. Tsai and C.T. Su, An inventory model with deteriorating items under inflation when a delay in payment is permissible, *Int. J. Prod. Econ.*, Vol. 63, pp. 207-214, 2000.

[6] B.R. Sarker, A.M.M. Jamal and S. Wang, Supply chain model for perishable products under inflation and permissible delay in payment, *Comp. Opns. Res.*, Vol. 27, pp. 59-75, 2000.

[7] A.M.M. Jamal, B.R. Sarker and S. Wang, An ordering policy for deteriorating items with allowable shortages and permissible delay in payment, *J. Opl. Res. Soc.*, Vol. 48, pp. 826-833, 1997.

[8] H.J. Chang and C.Y. Dye, An inventory model for deteriorating items with partial backlogging and permissible delay in payments, *Int. J. Syst. Sci.*, Vol. 32, pp. 345-352, 2001.

[9] H.J. Chang, C.H. Hung and C.Y. Dye, An inventory model for deteriorating items with linear trend demand under the condition of permissible delay in payments, *Prod. Plan. Cont.*, Vol. 12, pp. 274-282, 2001.

[10] M.S. Chen and C.C. Chuang, An analysis of light buyer's economic order model under trade credit, *Asia-Pacific J. Opl. Res.*, Vol. 16, pp. 23-34, 1999.

[11] H. Hwang and S.W. Shinn, Retailer's pricing and lot sizing policy for exponentially deteriorating products under the condition of permissible delay in payment, *Comp. Opns. Res.*, Vol. 24, pp. 539-547, 1997.

[12] A.M.M. Jamal, B.R. Sarker and S. Wang, Optimal payment time for a retailer under permitted delay of payment by the wholesaler, *Int. J. Prod. Econ.*, Vol. 66, pp. 59-66, 2000.

[13] B.R. Sarker, A.M.M. Jamal and S. Wang, Optimal payment time under permissible delay in payment for products with deterioration, *Prod. Plan. Cont.*, Vol. 11, pp. 380-390, 2000.

[14] J.T. Teng, On the economic order quantity under conditions of permissible delay in payments, *J. Opl. Res. Soc.*, Vol. 53, pp. 915-918, 2002.

[15] K.J. Chung, Y.F. Huang and C.K. Huang, The replenishment decision for EOQ inventory model under permissible delay in payments, *Opsearch*, Vol. 39, pp. 327-340, 2002.

[16] S.W. Shinn and H. Hwang, Optimal pricing and ordering policies for retailers under order-size-dependent delay in payments, *Comp. Opns. Res.*, Vol. 30, pp. 35-50, 2003.

[17] K.J. Chung and Y.F. Huang, The optimal cycle time for EPQ inventory model under permissible delay in payments, *Int. J. Prod. Econ.*, Vol. 84, pp. 307-318, 2003.

[18] Y.F. Huang and K.J. Chung, Optimal replenishment and payment policies in the EOQ model under cash discount and trade credit, *Asia-Pacific J. Opl. Res.*, Vol. 20, pp. 177-190, 2003.

[19] M.K. Salameh, N.E. Abboud, A.N. El-Kassar and R.E. Ghattas, Continuous review inventory model with delay in payments, *Int. J. Prod. Econ.*, Vol. 85, pp. 91-95, 2003.

[20] C.T. Chang, L.Y. Ouyang and J.T. Teng, An EOQ model for deteriorating items under supplier credits linked to ordering quantity, *Appl. Math. Modelling*, Vol. 27, pp. 983-996, 2003.

[21] K.J. Chung and J.J. Liao, Lot-sizing decisions under trade credit depending on the ordering quantity, *Comp. Opns. Res.*, Vol. 31, pp. 909-928, 2004.

[22] C.T. Chang, An EOQ model with deteriorating items under inflation when supplier credits linked to order quantity, *Int. J. Prod. Econ.*, Vol. 88, pp. 307-316, 2004.

[23] Y.F. Huang, Optimal retailer's replenishment policy for the EPQ model under supplier's trade credit policy, *Prod. Plan. Cont.*, Vol. 15, pp. 27-33, 2004.

[24] Y.F. Huang, Optimal retailer's ordering policies in the EOQ model under trade credit financing, *J. Opl. Res. Soc.*, Vol. 54, pp. 1011-1015, 2003.

[25] Y.F. Huang, An inventory model under two levels of trade credit and limited storage space derived without derivatives, *Appl. Math. Modelling*, Vol. 30, pp. 418-436, 2006.

[26] Y.F. Huang, Optimal retailer's replenishment decisions in the EPQ model under two levels of trade credit policy, *Eur. J. Opl. Res.*, Vol. 176, pp. 1575-1589, 2007.

KOLIČINA GOSPODARSKE NARUDŽBE TRGOVCA NA MALO U LANCU NABAVE U DVA NAVRATA POD DJELOMIČNIM TRGOVINSKIM KREDITOM

SAŽETAK

U ovom radu istražujemo politiku zaliha trgovca na malo kada on zauzima važnu poziciju u lancu nabave u dva navrata. To jest, pretpostavili smo da trgovac na malo može dobiti cijeli trgovinski kredit od dobavljača, a trgovac samo nudi djelomičan trgovinski kredit svojim mušterijama pod uvjetom trgovinskog kredita na dvije razine. Zatim ispitujemo sustav zaliha trgovca na malo kao problem smanjenja troškova s ciljem određivanja optimalne politike zaliha trgovca na malo u lancu nabave u dva navrata. Konačno, predočeni su numerički primjeri da bi se ilustrirali rezultati i dobio menadžerski uvid.

Ključne riječi*: zaliha, EOQ, trgovinski kredit na dvije razine, lanac nabave u dva navrata.*