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An EOQ Model for a Deteriorating Item with Two-Level Trade Credit Period under Selling Price and Advertisement Dependent Demand

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Abstract

In this paper, an EOQ model is developed for deteriorating items with a two-level credit period, where demand is depended on both selling price and advertising. The current market conditions highlight the significance of the selling price in customer decision-making process. It is noticed that both the selling price and advertisement effect on demand. As advertising itself may involve cost, if it effectively leads to increased demand, it can ultimately minimize the total cost of the product in an inventory model. Trade credit emerges as one of the most effective promotional strategies. Therefore, this research paper formulates an EOQ model under a two-level trade credit policy. In this policy, suppliers offer a permissible delay period to retailers, who in turn provide partial trade credit to customers. Deterioration is considered at a constant rate. The primary purpose of this paper is to reduce the overall inventory cost. Numerical examples are illustrated and sensitivity analysis is carried to highlight the findings of the suggested inventory model.

Subject Areas

Operational Research

Keywords

EOQ Model, Deterioration, Two-Level Trade Credit, Selling Price, Advertisement

1. Introduction

Trade credit plays an important role as it is always advantage to the customer to delay the payment to the supplier until the end of the period. In two-level trade credit policy, supplier allows a fixed credit period to the retailer to settle the account and retailer offers partial trade credit to his customers, where customers must pay some portion of the purchase amount at the time of order place and they get permissible delay period on rest amount to avoid non-payment risk.

It is necessary for any organization to maintain inventory who is dealing with deteriorating items. Deterioration is the decline in the quantity quality and effectiveness of an item over some time. All the goods and product depreciate sometimes partially and sometimes completely after deterioration. Items that deteriorate are those that degrade, spoil, evaporate, expire, or become invalid as time passes.

In the current position of the market, the selling price is a big factor for customers in selecting the item. The setting of a selling price is an important aspect of any product's success, as it can significantly impact both the profitability and demand. In practice, a higher selling price decreases the demand for the product, whereas a low price has the reverse effect.

Advertisement plays an important role in building awareness. Advertisement can help customers to understand how product can mark their wants and need. A well-crafted advertisement can influence a consumer's purchasing decision positively. An advertisement can help to leading to increased sales and revenue.

Hariga [1] created an EOQ model for deteriorating items with demand rate as a function of time. Bera [2] generated an EPQ inventory model with immediate part payment under stock-dependent demand for deteriorating items Jaggi and Mandeep [3] produced an EOQ model for deteriorating items under inflationary conditions with a constant deterioration rate and time-dependent demand rate. Alaa Fouad Mommena *et al.* [4] designed a two-storage inventory model where holding cost is time-varying and quantity discounts consider with trade credit policy. Teng *et al.* [5] built inventory model for linearly increasing demand with time under two-level trade credits. Teng and Lou [6] constructed an inventory model with upstream and downstream trade credits for the seller's optimal credit period and cycle length, where demand rare is a function of customer credit period. Jaggi *et al.* [7] invented optimal inventory model with demand rate that is a function of the customer's credit period under permissible delay in payment. Wu and Chan [8] developed lot sizing inventory policies where the deterioration rate is time-varying with constant demand and under the partial trade credit. Ebrahimi *et al.* [9] introduced inventory model with a market demand rate that follows a normal distribution. Mukharjee and Mahata [10] formed an inventory model for optimal replenishment and credit policy under two-level trade credit policies when demand depends on time and credit period. Ouyan *et al.* [11] studied EOQ model for deteriorating items where deterioration rate follows exponential distribution and demand rate is constant under two-level trade credits. Aggarwal and jaggy [12] introduced ordering policies for deterioration items. Bhaskar *et al.* [13] presented an inventory model for perishable items when the demand rate is selling price and time-dependent underprice discount and delay in payment. Ummeferva *et al.* [14] established an inventory model under greening degree dependent demand and reliability under two-level trade credit policy. Monalisha Tripathy *et al.* [15] obtained An EOQ inventory model under progressive financial trade credit for non-instantaneous deteriorating item with constant demand. Mamta Kumari and De [16] created an EOQ model for deteriorating items for analyzing retailers' optimal strategy under trade credit and return policy with nonlinear demand. Niota Shah and Vaghela [17] generated an EPQ model under two-level trade credits financing for deteriorating items where demand is selling price dependent demand. Chuan Zhang *et al.* [18] designed retailer's optimal credit policy at risk of customer default under partial trade credit where demand is a positive exponential function of customer's credit period. Jaggi *et al.* [19] built an optimal replenishment credit policy under two levels credit period. Mahata [20] constructed model for time-varying deterioration rate. Mahata [21] invented EPQ model for deterioration items when deterioration rate follows exponential distribution where demand and replenishment rate both are constant under partial trade credit policy. Chen *et al.* [22] developed inventory model with expiration date where demand is stock dependent. Hardik Soni [23] introduced optimal replenishment policy for deteriorating items under a level trade credit policy where demand is stock sensitive. Lou and Wang [24] formed optimal trade credit and order quantity where demand is a positive exponential function of the credit period. Bose *et al.* [25] studied an EOQ model for deterioration items and demand is linear time-dependent, shortages are considered under inflation. Wee [26] addressed inventory model for deterioration items when deterioration rate is constant and demand is known and decreases exponentially. Hollter and Mak [27] presented inventory replenishment policies for deteriorating items with a demand rate that decreases with negative exponential distribution. Wang and Tang [28] established an inventory model for optimal credit period and cycle time with time-varying deterioration rate and demand rate is positive exponential of credit period. Sharma [29] created an optimal trade credit policy for perishable items with stock-dependent demand rate. Singh *et al.* [30] generated an EOQ model for deterioration items where the deterioration rate is a function of preservation technology under trade credit policy and preservation technology with stock-dependent demand.

A significant amount of work has been accomplished regarding deteriorating items and trade credit with different types of demand. However, until now, no research work has been done in the past on deteriorating items under two-level trade credit where the demand is selling price and advertisement dependent.

This paper tries to build up the model on deteriorating items with selling price and advertisement dependent demand under two-level trade credit. This research work intends to determine the time length during which the item has no deterioration and the length of replenishment cycle. A numerical example is also given and a sensitivity analysis is carried out to understand the influence of observation of input parameters.

2. Notations

o: Order cost.

a: Fixed part of demand function ($a > o$).

b: Price sensitivity in demand function ($b > 0$).

A: Advertisement frequency

η : Advertising elasticity of the demand function.

c_h : Holding cost ($/unit).

c_d: Deterioration Cost ($/unit).

p: the selling Price ($/unit).

s: Purchasing Price ($/unit).

M: retailer's trade credit period offered by the supplier in years.

N: Customer's trade credit period offered by the retailer in year.

θ : Deterioration rate ($0 \le \theta < 1$).

I_c: Rate of interest charged by the supplier per dollar per year.

I_e: Rate of interest earned by the retailer per dollar per year.

t_1: Time length during which the item has no deterioration (in year).

$I_1(t)$: The inventory level at time when there is no deterioration (in year).

$I_2(t)$: The inventory level at time t when there is deterioration (in year).

γ : γ Of the total purchase price to be paid by the customer to the retailer's.

Q: The retailer's maximum order quantity.

T: The length of replenishment cycle (in year).

TC: Total average cost (in dollar).

3. Assumptions

The suggested model was constructed based on the following assumptions.

1) The demand function $D(A, p)$ of a product is considered as a multiplicative of the selling price p and advertisement frequency in the following way: $D(A, p) = (A+1)^{\eta}(a-bp)$; $a > 0$, $b > 0$.

2) Deterioration is considered in this model and the rate of deterioration is assumed as constant.

3) The infinite planning horizon is considered.

4) Shortages are not allowed.

5) two-level trade credit policies are implemented in this model. According to this policy, supplier offer a trade credit period to the retailer and retailer's offer a partial trade credit period to the customer.

4. Model Formulation

In this model initially, Q volume of items entered into the inventory system. Inventory system does not include the items. Items are not being immediately deteriorated during the period $(0, t_1)$ and consequently, the inventory is reduced only responding to the demand. Further during the time period $[t_1, T]$, stock loss is collective impact of demand as well as the deterioration.

$$\frac{dI_1(t)}{dt} = -(A+1)^{\eta}(a-bp); \quad a>0, \quad b>0, \quad 0<t<t_1 \tag{1}$$

$$\frac{dI_2(t)}{dt} = -(A+1)^{\eta}(a-bp) - \theta I_2(t); \quad t_1<t<T \tag{2}$$

By solving the above equations with boundary conditions $I_1(t)=Q$, at $t=0$, $I_1(t)=I_2(t)$ at $t=t_1$ and $I_2(t)=0$ at $t=T$ we have,

$$I_1(t) = (A+1)^{\eta}(a-bp)\left[\frac{1}{\theta}\left[\left(e^{\theta(T-t_1)}-1\right)+t_1-t\right]\right] \tag{3}$$

$$I_2(t) = \frac{(A+1)^{\eta}(a-bp)}{\theta}\left[e^{\theta(T-t)}-1\right], \quad t_1<t<T \tag{4}$$

At $t=t_1$ from Equations (3) and (4)

$$Q = (A+1)^{\eta}(a-bp)\left[T+\frac{\theta(T-t_1)^2}{2}\right] \tag{5}$$

The total cycle length consists of the following elements,

$$Ordering\ Cost = OC : o \tag{6}$$

Holding cost = *HC*:

$$c_h\left[(A+1)^{\eta}(a-bp)\left[\frac{\left(e^{\theta(T-t_1)}-1\right)t_1}{\theta}+\frac{t_1^2}{2}\right] + \frac{(A+1)^{\eta}(a-bp)}{\theta}\left[\frac{e^{\theta(T-t_1)}-1}{\theta}+t_1-T\right]\right] \tag{7}$$

Deterioration Cost = *DC*:

$$c_d\cdot\theta\left[(A+1)^{\eta}(a-bp)\left[\frac{\left(e^{\theta(T-t_1)}-1\right)t_1}{\theta}+\frac{t_1^2}{2}\right] + \frac{(A+1)^{\eta}(a-bp)}{\theta}\left[\frac{e^{\theta(T-t_1)}-1}{\theta}+t_1-T\right]\right] \tag{8}$$

Scenario 1: $N < M$

In this scenario, the customer's credit duration (N) given by retailers' is less than the retailer's credit period (M) given by the supplier.

Case 1: $M \le t_1$

In this case retailer earned interest in the time period (0, M) and he pay the interest from the duration (M, T). In this case interest payable and eared can be as follows.

Interest Paid = *IP*:

$$s\cdot I_c\left[(A+1)^{\eta}(a-bp)\left[\frac{e^{\theta(T-t_1)}-1}{\theta}(t_1-M)+t_1(t_1-M)-\left[\frac{t_1^2}{2}-\frac{M^2}{2}\right]\right] + \frac{(A+1)^{\eta}(a-bp)}{\theta}\left[\frac{e^{\theta(T-t_1)}-1}{\theta}+t_1-T\right]\right] \tag{9}$$

Interest Earned = *IE*:

$$p\cdot I_e\left[\left(A+1\right)^{\eta}\left(a-bp\right)\left[\gamma\left(\frac{M^2}{2}\right)+\left(\frac{M^2}{2}-\frac{N^2}{2}\right)\right]\right] \tag{10}$$

Retailer's average cost is

$$TC_1=\frac{1}{T}\left[OC+HC+DC+IP-IE\right]$$

$$\begin{aligned} TC_1=\frac{1}{T}&\left[o+c_h\left[\left(A+1\right)^{\eta}\left(a-bp\right)\left[\frac{\left(e^{\theta(T-t_1)}-1\right)t_1}{\theta}+\frac{t_1^2}{2}\right]\right.\right.\\ &\left.+\frac{\left(A+1\right)^{\eta}\left(a-bp\right)}{\theta}\left[\frac{e^{\theta(T-t_1)}-1}{\theta}+t_1-T\right]\right]\\ &+c_d\cdot\theta\left[\left(A+1\right)^{\eta}\left(a-bp\right)\left[\frac{\left(e^{\theta(T-t_1)}-1\right)t_1}{\theta}+\frac{t_1^2}{2}\right]\right.\\ &\left.+\left[\frac{\left(A+1\right)^{\eta}\left(a-bp\right)}{\theta}\left[\frac{e^{\theta(T-t_1)}-1}{\theta}+t_1-T\right]\right]\right]\\ &+s\cdot I_c\left[\left(A+1\right)^{\eta}\left(a-bp\right)\left[\frac{\left(e^{\theta(T-t_1)}-1\right)t_1}{\theta}+\frac{t_1^2}{2}\right]\right.\\ &\left.+\frac{\left(A+1\right)^{\eta}\left(a-bp\right)}{\theta}\left[\frac{e^{\theta(T-t_1)}-1}{\theta}+t_1-T\right]\right]\\ &\left.-p\cdot I_e\left[\left(A+1\right)^{\eta}\left(a-bp\right)\left[\gamma\left(\frac{M^2}{2}\right)+\left(\frac{M^2}{2}-\frac{N^2}{2}\right)\right]\right]\right] \end{aligned} \tag{11}$$

Now, for minimization of total average cost per unit time, the optimal value of T Can be acquired by solving the following equation.

$$\frac{\partial TC_1}{\partial T}=0$$

Given that they meet the following condition

$$\frac{\partial^2 TC_1}{\partial T^2}>0$$

Case II: $t_1 < N < M \le T$

In this case retailer's trade credit period is greater than the time t_1. In this case retailer earned interest in the time period (0, *M*) and he/she pays the interest from the duration (*M*, *T*). In this case interest payable and earned are as follows.

Interest Paid = *IP*:

$$s\cdot I_c\left[\frac{\left(A+1\right)^{\eta}\left(a-bp\right)}{\theta}\left[\frac{e^{\theta(T-M)}-1}{\theta}+M-T\right]\right] \tag{12}$$

Interest Earned = *IE*:

$$p \cdot I_e \left[(A+1)^{\eta} (a-bp) \left[\frac{N^2}{2}(\gamma - 1) + \frac{M^2}{2} \right] \right] \quad (13)$$

Retailer's average cost is

$$TC_2 = \frac{1}{T}\left[OC + HC + DC + IP - IE \right]$$

$$\begin{aligned} TC_2 = \frac{1}{T} \Bigg[& o + c_h \left[(A+1)^{\eta} (a-bp) \left[\frac{\left(e^{\theta(T-t_1)} - 1 \right) t_1}{\theta} + \frac{t_1^2}{2} \right] \right. \\ & \left. + \frac{(A+1)^{\eta}(a-bp)}{\theta} \left[\frac{e^{\theta(T-t_1)} - 1}{\theta} + t_1 - T \right] \right] \\ & + c_d \cdot \theta \left[(A+1)^{\eta} (a-bp) \left[\frac{\left(e^{\theta(T-t_1)} - 1 \right) t_1}{\theta} + \frac{t_1^2}{2} \right] \right. \\ & \left. + \left[\frac{(A+1)^{\eta}(a-bp)}{\theta} \left[\frac{e^{\theta(T-t_1)} - 1}{\theta} + t_1 - T \right] \right] \right] \\ & + s \cdot I_c \left[\frac{(A+1)^{\eta}(a-bp)}{\theta} \left[\frac{e^{\theta(T-M)} - 1}{\theta} + M - T \right] \right] \\ & - p \cdot I_e \left[(A+1)^{\eta} (a-bp) \left[\frac{N^2}{2}(\gamma - 1) + \frac{M^2}{2} \right] \right] \Bigg] \end{aligned} \quad (14)$$

Now, for minimization of total average cost per unit time, the optimal value of T Can be acquired by solving the following equation.

$$\frac{\partial TC_2}{\partial T} = 0$$

Given that they meet the following condition

$$\frac{\partial^2 TC_2}{\partial T^2} > 0$$

Scenario 2. $M < N$

In this scenario, the customer's credit duration (N) given by retailers' is greater than the retailer's credit period (M) given by the supplier.

Case III: $M < N \le t_1$

In this case retailer's trade credit period and customers trade credit both are less than the time t_1. In this case retailer earned interest in the time period (0, M) and he/she pays the interest from the duration (M, T). In this case interest payable is as follows

Interest Paid = IP:

$$\begin{aligned} s \cdot I_c \Bigg[& (A+1)^{\eta} (a-bp) \left[\frac{e^{\theta(T-t_1)} - 1}{\theta} (t_1 - M) + t_1 (t_1 - M) - \left[\frac{t_1^2}{2} - \frac{M^2}{2} \right] \right] \\ & + \frac{(A+1)^{\eta}(a-bp)}{\theta} \left[\frac{e^{\theta(T-t_1)} - 1}{\theta} + t_1 - T \right] \Bigg] \end{aligned} \quad (15)$$

Interest earned = *IE*:

$$IE = p \cdot I_e \cdot \gamma \left[(A+1)^{\eta} (a-bp) \left[\frac{M^2}{2} \right] \right] \tag{16}$$

Retailer's average cost is

$$TC_3 = \frac{1}{T}\left[OC + HC + DC + IP - IE \right]$$

$$\begin{aligned} TC_3 = \frac{1}{T} \Bigg[& o + c_h \Bigg[(A+1)^{\eta} (a-bp) \left[\frac{\left(e^{\theta(T-t_1)} - 1 \right) t_1}{\theta} + \frac{t_1^2}{2} \right] \\ & + \frac{(A+1)^{\eta} (a-bp)}{\theta} \left[\frac{e^{\theta(T-t_1)} - 1}{\theta} + t_1 - T \right] \Bigg] \\ & + c_d \cdot \theta \Bigg[(A+1)^{\eta} (a-bp) \left[\frac{\left(e^{\theta(T-t_1)} - 1 \right) t_1}{\theta} + \frac{t_1^2}{2} \right] \\ & + \left[\frac{(A+1)^{\eta} (a-bp)}{\theta} \left[\frac{e^{\theta(T-t_1)} - 1}{\theta} + t_1 - T \right] \right] \Bigg] \\ & + s \cdot I_c \Bigg[(A+1)^{\eta} (a-bp) \left[\frac{\left(e^{\theta(T-t_1)} - 1 \right) t_1}{\theta} + \frac{t_1^2}{2} \right] \\ & + \frac{(A+1)^{\eta} (a-bp)}{\theta} \left[\frac{e^{\theta(T-t_1)} - 1}{\theta} + t_1 - T \right] \Bigg] \\ & - p \cdot I_e \cdot \gamma \left[(A+1)^{\eta} (a-bp) \left[\frac{M^2}{2} \right] \right] \Bigg] \end{aligned} \tag{17}$$

Now, for minimization of total average cost per unit time, the optimal value of T Can be acquired by solving the following equation.

$$\frac{\partial TC_3}{\partial T} = 0$$

Given that they meet the following condition

$$\frac{\partial^2 TC_3}{\partial T^2} > 0$$

Case IV: $t_1 < M < N \le T$

Interest payable amount and interest earned amount for this case is as follows.

Interest Paid:

$$IP = s \cdot I_c \left[\frac{(A+1)^{\eta} (a-bp)}{\theta} \left[\frac{e^{\theta(T-M)} - 1}{\theta} + M - T \right] \right] \tag{18}$$

Interest Earned:

$$IE = p \cdot I_e \cdot \gamma \left[(A+1)^{\eta} (a-bp) \left[\frac{M^2}{2} \right] \right] \tag{19}$$

Retailer's average cost is

$$TC_4 = \frac{1}{T}\left[OC + HC + DC + IP - IE\right]$$

$$\begin{aligned} TC_4 = \frac{1}{T}\Bigg[& o + c_h\Bigg[(A+1)^{\eta}(a-bp)\left[\frac{\left(e^{\theta(T-t_1)}-1\right)t_1}{\theta} + \frac{t_1^2}{2}\right] \\ & + \frac{(A+1)^{\eta}(a-bp)}{\theta}\left[\frac{e^{\theta(T-t_1)}-1}{\theta} + t_1 - T\right]\Bigg] \\ & + c_d \cdot \theta\Bigg[(A+1)^{\eta}(a-bp)\left[\frac{\left(e^{\theta(T-t_1)}-1\right)t_1}{\theta} + \frac{t_1^2}{2}\right] \\ & + \left[\frac{(A+1)^{\eta}(a-bp)}{\theta}\left[\frac{e^{\theta(T-t_1)}-1}{\theta} + t_1 - T\right]\right]\Bigg] \\ & + s \cdot I_c\left[\frac{(A+1)^{\eta}(a-bp)}{\theta}\left[\frac{e^{\theta(T-M)}-1}{\theta} + M - T\right]\right] \\ & - p \cdot I_e \cdot \gamma\left[(A+1)^{\eta}(a-bp)\left[\frac{M^2}{2}\right]\right]\Bigg] \end{aligned} \tag{20}$$

Now, for minimization of total average cost per unit time, the optimal value of T Can be acquired by solving the following equation.

$$\frac{\partial TC_4}{\partial T} = 0$$

Given that they meet the following condition

$$\frac{\partial^2 TC_4}{\partial T^2} > 0$$

5. Numerical Examples

A number of examples have been presented to illustrate the proposed inventory model

Scenario 1: $N < M$

Case I: $M \le t_1$

$A = 300, b = 5, s = 10, \eta = 0.01, \theta = 0.02, \gamma = 0.03, I_c = 0.03, I_e = 0.03,$
$M = 0.002, N = 0.0022, o = 50, c_h = 2, c_d = 2, A = 2, p = 55.$

Following results obtained:

$$t_1 = 0.0024, T = 1.1566, TC = 77.690691$$

Case II: $t_1 < N < M \le T$

$A = 300, b = 5, s = 10, \eta = 0.01, \theta = 0.02, \gamma = 0.03, I_c = 0.03, I_e = 0.03,$
$M = 0.3, N = 0.2, o = 50, c_h = 2, c_d = 2, A = 2, p = 55.$

Following results obtained:

$$t_1 = 0.0022, T = 1.1581, TC = 74.771$$

Scenario 2. $M < N$

Case III: $M < N \le t_1$

$$A = 300, b = 5, s = 10, \eta = 0.01, \theta = 0.02, \gamma = 0.03, I_c = 0.03, I_e = 0.03,$$
$$M = 0.002, N = 0.0022, o = 50, c_h = 2, c_d = 2, A = 2, p = 55.$$

Following results obtained:

$$t_1 = 0.0024, T = 1.1566, TC = 77.690691$$

Case IV: $t_1 < M < N \le T$

$$A = 300, b = 5, s = 5, \eta = 0.01, \theta = 0.02, \gamma = 0.03, I_c = 0.03, I_e = 0.03,$$
$$M = 0.20, N = 0.25, o = 50, c_h = 2, c_d = 2, A = 2, p = 55.$$

Following results obtained:

$$t_1 = 0.0022, T = 1.1584, TC = 73.880402$$

6. Sensitivity Analysis

Based on above numerical example, the sensitivity analysis is executed to understand the influence of observation of input parameters on the time length during which the item has no deterioration t_1 and the length of replenishment cycle T and the total average cost obtained. The results are determined by keeping the other parameter constant and transforming one parameter at a time.

Table 1. The results of the sensitivity analysis.

Parameter	Changes	t_1	T	TC
	280	0.0088	1.6619	39.154838
	290	0.0043	1.3573	58.797902
a	300	0.0024	1.1811	73.880402
	310	0.0011	1.0165	86.731660
	320	0.0005	0.9090	97.691177
	4.50	0.0002	0.8668	104.91616
	4.75	0.0010	0.9963	90.849581
b	5.00	0.0024	1.1811	73.880402
	5.25	0.0058	1.4706	51.932030
	5.50	0.0149	1.9712	19.938527
	1.6	0.0024	1.1817	73.830960
	1.8	0.0024	1.1814	73.856483
A	2.0	0.0024	1.1811	73.880400
	2.2	0.0024	1.1809	73.902205
	2.4	0.0024	1.1806	73.923499
	52	0.0009	1.0834	87.667034
	54	0.0017	1.1053	80.541784
p	55	0.0024	1.1811	73.880402
	56	0.0033	1.2703	66.669868
	57	0.0045	1.3766	58.627957

Continued

s	3	0.0025	1.1905	73.225942
	4	0.0024	1.1858	73.573765
	5	0.0024	1.1811	73.880402
	6	0.0023	1.1765	74.262668
	7	0.0023	1.1719	74.603782
η	0.006	0.0024	1.1829	73.728996
	0.008	0.0024	1.1820	73.804655
	0.010	0.0024	1.1811	73.880402
	0.012	0.0024	1.1802	73.956237
	0.014	0.0024	1.1793	74.087640
θ	0.010	0.0017	1.1275	73.655804
	0.015	0.0022	1.1652	73.793739
	0.020	0.0024	1.1811	73.880402
	0.025	0.0024	1.1890	74.040137
	0.030	0.0025	1.1930	74.231893
γ	0.01	0.0024	1.1811	73.880402
	0.02	0.0024	1.1811	73.880402
	0.03	0.0024	1.1811	73.880402
	0.04	0.0024	1.1811	73.880402
	0.05	0.0024	1.1811	73.880402
I_c	0.01	0.0025	1.1968	72.719034
	0.02	0.0025	1.1889	73.303411
	0.03	0.0024	1.1811	73.880402
	0.04	0.0023	1.1734	74.450672
	0.05	0.0022	1.1659	75.013655
I_e	0.01	0.0024	1.1857	74.316927
	0.02	0.0024	1.1834	74.098962
	0.03	0.0024	1.1811	73.880402
	0.04	0.0024	1.1788	73.661244
	0.05	0.0023	1.1765	73.440979
M	0.10	0.0024	1.1857	74.710185
	0.15	0.0024	1.1838	74.332650
	0.20	0.0024	1.1811	73.880402
	0.25	0.0023	1.1776	73.352200
	0.30	0.0023	1.1733	72.748084
N	0.15	0.0024	1.1811	73.88040
	0.20	0.0024	1.1811	73.88040
	0.25	0.0024	1.1811	73.88040
	0.30	0.0024	1.1811	73.88040
	0.35	0.0024	1.1811	73.88040

Continued

	40	0.0016	1.0879	65.638703
	45	0.0020	1.1375	69.855879
o	50	0.0024	1.1811	73.88040
	55	0.0028	1.2199	79.432863
	60	0.0031	1.2545	81.480134
	1	0.0050	1.4115	55.559037
	1.5	0.0034	1.2842	64.559297
c_h	2	0.0024	1.1811	73.88040
	2.5	0.0017	1.0960	81.701349
	3	0.0011	1.0245	88.888459
	1	0.0024	1.1849	73.551559
	1.5	0.0024	1.1830	73.716117
c_d	2	0.0024	1.1811	73.88040
	2.5	0.0024	1.1793	74.043700
	3	0.0023	1.1774	74.206938

The following results are obtained from **Table 1**.

i) With the increase in the value "a", time length within which the item has no deterioration t_1 and optimal cycle length decreases at the same time total average cost per year increases.

ii) As the value of b increases value of t_1 *i.e.* Time length within which the item has no deterioration and optimal cycle length T increases at the same time total average cost per year decreases.

iii) It can be seen that increase in advertisement frequency, time length within which the item has no deterioration remain constant, whereas there is a slight decline in replenishment time interval at the same time total average cost increase.

iv) As the value of p increases value of t_1 *i.e.* Time length within which the item has no deterioration and optimal cycle length T increases at the same time total average cost per year decreases.

v) As the increase in value of θ, time length within which the item has no deterioration and optimal cycle length T increases at the same time total average cost per year also increases.

vi) With the increase in the value of s, time length within which the item has no deterioration and optimal cycle length T slightly decreases as well as total average cost slightly increases.

vii) It can be seen that increase in γ values, time within which the item has no deterioration, replenishment cycle length as well as total average cost remain constant.

viii) It can be seen that increase in η values, time length within which the item has no deterioration remain constant as well as replenishment cycle length slightly decreases and total average cost increases.

ix) With the increase in the value of I_c, it can be seen that time length within which the item has no deterioration t_1 and optimal cycle length T Decreases at the same time total average cost per year increases.

x) With the increase in the value of I_e, time length within which the item has no deterioration and optimal cycle length T slightly decreases at the same time total average cost also decreases.

xi) With the increase in the retailer's credit period offered by supplier M, time length within which the item has no deterioration and optimal cycle length T slightly decreases at the same time total average cost also decreases.

xii) With the increase in the customer's credit period offered by retailer N, time length within which the item has no deterioration, replenishment cycle length as well as total average cost remain constant.

xiii) As ordering cost o increases, simultaneously time length within which the item has no deterioration and optimal cycle length T increases at the same time total average cost per year also increases.

xiv) With the increase in holding cost c_h, time length within which the item has no deterioration t_1 and optimal cycle length decreases at the same time total average cost per year increases.

xv) With the increase in the value of c_d, time length within which the item has no deterioration and optimal cycle length T slightly decreases at the same time total average cost also increases.

7. Conclusions

In this paper, we have developed an EOQ model for a deteriorating item with two-level trade credit period under selling price and advertisement dependent demand. We present the optimal strategy to minimize total inventory costs. As in this model, two-level trade credit policy is considered, so this model is more beneficial for retailers to make their inventory strategy to maximize their profit. As a result, the retailer can better manage their financial expenses. Sensitivity analysis of the solution to changes in the values of different parameters has been discussed. It is observed that changes in the value of price sensitivity in demand function (b), advertisement frequency (A), selling price (p), retailer's credit period (M) as well as holding cost (c_h) and deterioration cost (c_d) lead to significant effects on the time length during which the item has no deterioration, replenishment cycle length, and total average cost.

The scope of this work can be expanded in the following directions. One possible extension could be allowing shortages; one could consider preservation technology to reduce deterioration in future research.

Conflicts of Interest

The authors declare no conflicts of interest.

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