Inventory Model for Imperfect Quality Items with Different Deterioration Rates under Inflation and Permissible Delay in Payments

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Abstract:- **Many times it happens that units produced or ordered are not of 100% good quality. A deterministic inventory model for imperfect quality items is developed when deterioration rate is different during a cycle with permissible delay in payment under inflation. Here it is assumed that holding cost is time dependent. Demand is considered as linear function of time. Numerical example is taken to support the model.**

Key Words: **Inventory model, Varying Deterioration, Linear demand, Defective items, Inflation, Permissible Delay**

I. INTRODUCTION

Deterioration effect cannot be ignored for many items in real life. Inventory model with constant rate of deterioration was developed by Ghare and Schrader [5]. The model was extended by Covert and Philip [4] by considering variable rate of deterioration. Other related work for deteriorating items are found in (Nahmias [10], Raffat [13], Ruxian, et al [14]).

Many times it happens that units produced or ordered are not of 100% good quality. A model of imperfect production quantity was developed by establishing relationship between demand dependent unit production cost and imperfect production process by Cheng [3]. An inventory model in which items received are of defective quality and after 100% screening process, imperfect items are withdrawn from the inventory and sold at a discounted price was considered by Salmeh and Jaber [15]. Patel and Patel [12] developed an EOQ model for deteriorating items with imperfect quality items. Patel and Sheikh [11] developed an inventory model with different deterioration rates and time varying holding cost.

Goyal [6] was the first to develop an economic order quantity model under the condition of permissible delay in payments. The model was extended by Aggarwal and Jaggi [1] to consider the deteriorating items. Aggarwal and Jaggi's [1] model was further extended by Jamal et al.[8] to consider shortages. Teng et al. [16] developed an optimal pricing and lot sizing model by considering price sensitive demand under permissible delay in payments. Jaggi et al. [7] developed an inventory model for deteriorating items with imperfect quality under permissible delay in payment. Chang et al. [2] has given a literature review on inventory model under trade credit. An inventory model for exponentially deteriorating items under conditions of permissible delay in payments was developed by Min et al. [9].

Generally the products are such that initially there is no deterioration. Deterioration starts after certain time and again after certain time the rate of deterioration increases with time. Here we have used such a concept and developed the deteriorating items inventory models.

In this paper we have developed an inventory model for imperfect quality items with different deterioration rates for the cycle time under inflation and permissible delay in payments. Holding cost is taken as function of time. Shortages are not allowed. To illustrate the model, numerical example is provided. Sensitivity analysis for major parameters is also carried out.

II. ASSUMPTIONS AND NOTATIONS

NOTATIONS

The following notations are used for the development of the model:

D(t) : Demand rate is a linear function of time t ($a+bt$, $a>0$, $0<b<1$)
c : Purchasing cost per unit
p : Selling price per unit
d : defective items (%)
1-d : good items (%)
λ : Screening rate
SR : Sales revenue
A : Replenishment cost per order for
z : Screening cost per unit
p_d : Price of defective items per unit
h(t) : Variable Holding cost ($x + yt$, $x>0$, $0<y<1$)
M : Permissible period of delay in settling the accounts with the supplier
I_e : Interest earned per year
I_p : Interest paid in stocks per year
t_1 : Screening time
T : Length of inventory cycle
I(t) : Inventory level at any instant of time t, $0 \le t \le T$

Q : Order quantity
θ : Deterioration rate during $\mu_1 \le t \le \mu_2$, $0< \theta<1$
θt : Deterioration rate during , $\mu_2 \le t \le T$, $0< \theta<1$
π : Total relevant profit per unit time.

ASSUMPTIONS:

The following assumptions are considered for the development of model.

- The demand of the product is declining as a linear function of time.
- Replenishment rate is infinite and instantaneous.
- Lead time is zero.
- Shortages are not allowed.
- The screening process and demand proceeds simultaneously but screening rate (λ) is greater than the demand rate i.e. $\lambda > (a+bt)$.
- The defective items are independent of deterioration.
- Deteriorated units can neither be repaired nor replaced during the cycle time.
- A single product is considered.
- Holding cost is time dependent.
- The screening rate (λ) is sufficiently large. In general, this assumption should be acceptable since the automatic screening machine usually takes only little time to inspect all items produced or purchased.
- During the time, the account is not settled; generated sales revenue is deposited in an interest bearing account. At the end of the credit period, the account is settled as well as the buyer pays off all units sold and starts paying for the interest charges on the items in stocks.

III. THE MATHEMATICAL MODEL AND ANALYSIS

In the following situation, Q items are received at the beginning of the period. Each lot having a d % defective items. The nature of the inventory level is shown in the given figure, where screening process is done for all the received items at the rate of λ units per unit time which is greater than demand rate for the time period 0 to t_1. During the screening process the demand occurs parallel to the screening process and is fulfilled from the goods which are found to be of perfect quality by screening process. The defective items are sold immediately after the screening process at time t_1 as a single batch at a discounted price. After the screening process at time t_1 the inventory level will be $I(t_1)$ and at time T, inventory level will become zero due to demand and partially due to deterioration.

Also here $$t_1 = \frac{Q}{\lambda} \tag{1}$$

and defective percentage (d) is restricted to

$$d \le 1 - \frac{(a+bt)}{\lambda} \tag{2}$$

Let I(t) be the inventory at time t ($0 \le t \le T$) as shown in figure.

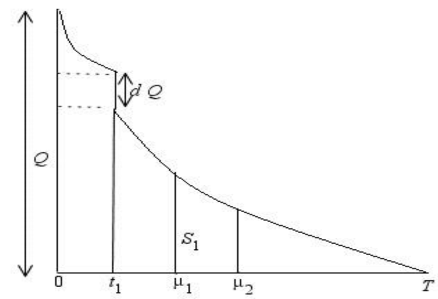


Figure 1

The differential equations which describes the instantaneous states of I(t) over the period (0, T) is given by

$$\frac{dI(t)}{dt} = -(a + bt), \qquad 0 \le t \le \mu_1 \tag{3}$$

$$\frac{dI(t)}{dt} + \theta I(t) = -(a + bt), \qquad \mu_1 \le t \le \mu_2 \tag{4}$$

$$\frac{dI(t)}{dt} + \theta t I(t) = -(a + bt), \qquad \mu_2 \le t \le T \tag{5}$$

with initial conditions $I(0) = Q$, $I(\mu_1) = S_1$ and $I(T) = 0$.
Solutions of these equations are given by

$$I(t) = Q - (at + \frac{1}{2}bt^2), \tag{6}$$

$$I(t) = \begin{bmatrix} a(\mu_1 - t) + \frac{1}{2}b(\mu_1^2 - t^2) + \frac{1}{2}a\theta(\mu_1^2 - t^2) \\ + \frac{1}{3}b\theta(\mu_1^3 - t^3) - a\theta t(\mu_1 - t) - \frac{1}{2}b\theta t(\mu_1^2 - t^2) \end{bmatrix} + S_1\left[1 + \theta(\mu_1 - t)\right] \tag{7}$$

$$I(t) = \begin{bmatrix} a(T - t) + \frac{1}{2}b(T^2 - t^2) + \frac{1}{6}a\theta(T^3 - t^3) \\ + \frac{1}{8}b\theta(T^4 - t^4) - \frac{1}{2}a\theta t^2(T - t) - \frac{1}{4}b\theta t^2(T^2 - t^2) \end{bmatrix}. \tag{8}$$

(by neglecting higher powers of θ)

After screening process, the number of defective items at time t_1 is dQ.

So effective inventory level during $t_1 \le t \le T$ is given by

$$I(t) = -(at + \frac{1}{2}bt^2) + Q(1-d). \tag{9}$$

From equation (6), putting $t = \mu_1$, we have

$$Q = S_1 + \left(a\mu_1 + \frac{1}{2}b\mu_1^2\right). \tag{10}$$

From equations (7) and (8), putting $t = \mu_2$, we have

$$I(\mu_2) = \begin{bmatrix} a(\mu_1 - \mu_2) + \frac{1}{2}b(\mu_1^2 - \mu_2^2) + \frac{1}{2}a\theta(\mu_1^2 - \mu_2^2) \\ +\frac{1}{3}b\theta(\mu_1^3 - \mu_2^3) - a\theta\mu_2(\mu_1 - \mu_2) - \frac{1}{2}b\theta\mu_2(\mu_1^2 - \mu_2^2) \end{bmatrix} + S_1\left[1 + \theta(\mu_1 - \mu_2)\right] \tag{11}$$

$$I(\mu_2) = \begin{bmatrix} a(T - \mu_2) + \frac{1}{2}b(T^2 - \mu_2^2) + \frac{1}{6}a\theta(T^3 - \mu_2^3) \\ +\frac{1}{8}b\theta(T^4 - \mu_2^4) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta\mu_2^2(T^2 - \mu_2^2) \end{bmatrix}. \tag{12}$$

So from equations (11) and (12), we get

$$S_1 = \frac{1}{\left[1 + \theta(\mu_1 - \mu_2)\right]} \begin{bmatrix} a(T - \mu_2) + \frac{1}{2}b(T^2 - \mu_2^2) + \frac{1}{6}a\theta(T^3 - \mu_2^3) \\ +\frac{1}{8}b\theta(T^4 - \mu_2^4) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta\mu_2^2(T^2 - \mu_2^2) \\ -a(\mu_1 - \mu_2) - \frac{1}{2}b(\mu_1^2 - \mu_2^2) - \frac{1}{2}a\theta(\mu_1^2 - \mu_2^2) \\ -\frac{1}{3}b\theta(\mu_1^3 - \mu_2^3) + a\theta\mu_2(\mu_1 - \mu_2) + \frac{1}{2}b\theta\mu_2(\mu_1^2 - \mu_2^2) \end{bmatrix}. \tag{13}$$

Putting value of S_1 from equation (13) into equation (10), we have

$$Q = \frac{1}{\left[1 + \theta(\mu_1 - \mu_2)\right]} \begin{bmatrix} a(T - \mu_2) + \frac{1}{2}b(T^2 - \mu_2^2) + \frac{1}{6}a\theta(T^3 - \mu_2^3) \\ +\frac{1}{8}b\theta(T^4 - \mu_2^4) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta\mu_2^2(T^2 - \mu_2^2) \\ -a(\mu_1 - \mu_2) - \frac{1}{2}b(\mu_1^2 - \mu_2^2) - \frac{1}{2}a\theta(\mu_1^2 - \mu_2^2) \\ -\frac{1}{3}b\theta(\mu_1^3 - \mu_2^3) + a\theta\mu_2(\mu_1 - \mu_2) + \frac{1}{2}b\theta\mu_2(\mu_1^2 - \mu_2^2) \end{bmatrix} + \left(a\mu_1 + \frac{1}{2}b\mu_1^2\right). \tag{14}$$

Using (14) in (6), we have

$$I(t) = \frac{1}{\left[1 + \theta(\mu_1 - \mu_2)\right]} \begin{bmatrix} a(T - \mu_2) + \frac{1}{2}b(T^2 - \mu_2^2) + \frac{1}{6}a\theta(T^3 - \mu_2^3) \\ +\frac{1}{8}b\theta(T^4 \mu_2^4) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta\mu_2^2(T^2 - \mu_2^2) \\ -a(\mu_1 - \mu_2) - \frac{1}{2}b(\mu_1^2 - \mu_2^2) - \frac{1}{2}a\theta(\mu_1^2 - \mu_2^2) \\ -\frac{1}{3}b\theta(\mu_1^3 - \mu_2^3) + a\theta\mu_2(\mu_1 - \mu_2) + \frac{1}{2}b\theta\mu_2(\mu_1^2 - \mu_2^2) \end{bmatrix} + a(\mu_1 - t)\ \frac{1}{2}b(\mu_1^2 - t^2). \tag{15}$$

Similarly, using (14) in (9), we have

$$I(t) = \frac{(1-d)}{\left[1 + \theta(\mu_1 - \mu_2)\right]} \begin{bmatrix} a(T - \mu_2) + \frac{1}{2}b(T^2 - \mu_2^2) + \frac{1}{6}a\theta(T^3 - \mu_2^3) \\ +\frac{1}{8}b\theta(T^4 - \mu_2^4) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta\mu_2^2(T^2 - \mu_2^2) \\ -a(\mu_1 - \mu_2) - \frac{1}{2}b(\mu_1^2 - \mu_2^2) - \frac{1}{2}a\theta(\mu_1^2 - \mu_2^2) \\ -\frac{1}{3}b\theta(\mu_1^3 - \mu_2^3) + a\theta\mu_2(\mu_1 - \mu_2) + \frac{1}{2}b\theta\mu_2(\mu_1^2 - \mu_2^2) \end{bmatrix} + (1-d)\left(a\mu_1 + \frac{1}{2}b\mu_1^2\right) - \left(at + \frac{1}{2}bt^2\right) \tag{16}$$

Similarly putting value of S_1 from equation (13) in equation (7), we have

$$I(t) = \frac{\left[1 + \theta(\mu_1 - t)\right]}{\left[1 + \theta(\mu_1 - \mu_2)\right]} \begin{bmatrix} a(T - \mu_2) + \frac{1}{2}b(T^2 - \mu_2^2) + \frac{1}{6}a\theta(T^3 - \mu_2^3) \\ +\frac{1}{8}b\theta(T^4 - \mu_2^4) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta\mu_2^2(T^2 - \mu_2^2) \\ -a(\mu_1 - \mu_2) - \frac{1}{2}b(\mu_1^2 - \mu_2^2) - \frac{1}{2}a\theta(\mu_1^2 - \mu_2^2) \\ -\frac{1}{3}b\theta(\mu_1^3 - \mu_2^3) + a\theta\mu_2(\mu_1 - \mu_2) + \frac{1}{2}b\theta\mu_2(\mu_1^2 - \mu_2^2) \end{bmatrix} + \begin{bmatrix} a(\mu_1 - t) + \frac{1}{2}b(\mu_1^2 - t^2) + \frac{1}{2}a\theta(\mu_1^2 - t^2) \\ +\frac{1}{3}b\theta(\mu_1^3 - t^3) - a\theta t(\mu_1 - t) - \frac{1}{2}b\theta t(\mu_1^2 - t^2) \end{bmatrix} \tag{17}$$

Based on the assumptions and descriptions of the model, the total annual relevant profit (μ), include the following elements:

(i) Ordering cost (OC) = A (18)

(ii) Screening cost (SrC) = zQ (19)

(iii) $$HC = \int_0^T (x+yt)I(t)e^{-Rt}dt$$

$$= \int_0^{t_1} (x+yt)I(t)e^{-Rt}dt + \int_{t_1}^{\mu_1} (x+yt)I(t)e^{-Rt}dt + \int_{\mu_1}^{\mu_2} (x+yt)I(t)e^{-Rt}dt + \int_{\mu_2}^{T} (x+yt)I(t)e^{-Rt}dt \quad (20)$$

(iv) $$DC = c\left(\int_{\mu_1}^{\mu_2} \theta I(t)e^{-Rt}dt + \int_{\mu_2}^{T} \theta t I(t)e^{-Rt}dt\right) \quad (21)$$

(v) $$SR = \left(p\int_0^T (a+bt)e^{-Rt}dt + p_d dQ\right) \quad (22)$$

To determine the interest earned, there will be two cases i.e.

Case I: (0≤M≤ T) and Case II: (0≤ T≤ M).

Case I: (0≤M≤T): In this case the retailer can earn interest on revenue generated from the sales up to M. Although, he has to settle the accounts at M, for that he has to arrange money at some specified rate of interest in order to get his remaining stocks financed for the period M to T.

(vi) Interest earned per cycle:

$$IE_1 = pI_e\int_0^M (a+bt)te^{-Rt}dt \quad (23)$$

Case II: (0 ≤T ≤ M):

In this case, the retailer earns interest on the sales revenue up to the permissible delay period. So

(vii) Interest earned up to the permissible delay period is:

$$IE_2 = pI_e\left[\int_0^T (a+bt)te^{-Rt}dt + (a+bT)T(M-T)\right] \quad (24)$$

To determine the interest payable, there will be four cases i.e.

Interest payable per cycle for the inventory not sold after the due period M is

Case I: (0≤M≤μ_1):

(viii) $$IP_1 = cI_p\int_M^T I(t)e^{-Rt}dt$$

$$= cI_p\left(\int_M^{\mu_1} I(t)e^{-Rt}dt + \int_{\mu_1}^{\mu_2} I(t)e^{-Rt}dt + \int_{\mu_2}^{T} I(t)e^{-Rt}dt\right) \quad (25)$$

Case II: (μ_1≤M≤ μ_2):

(ix) $$IP_2 = cI_p\int_M^T I(t)e^{-Rt}dt$$

$$= cI_p\left(\int_M^{\mu_2} I(t)e^{-Rt}dt + \int_{\mu_2}^{T} I(t)e^{-Rt}dt\right) \quad (26)$$

Case III: (μ_2≤M≤T):

(x) $$IP_3 = cI_p\int_M^T I(t)e^{-Rt}dt \quad (27)$$

Case IV: (T≤M≤T):

(xi) $IP_4 = 0$ (28)

(by neglecting higher powers of θ and R)

The total profit (π_i), i=1,2,3 and 4 during a cycle consisted of the following:

$$\pi_i = \frac{1}{T}\left[SR - OC - SrC - HC - DC - IP_i + IE_i\right] \quad (29)$$

Substituting values from equations (14) to (28) in equation (29), we get total profit per unit. Putting $\mu_1 = v_1T$, $\mu_2 = v_2T$ in equation (29), we get profit in terms of T for the four cases will be as under:

$$\pi_1 = \frac{1}{T}\left[SR - OC - SrC - HC - DC - IP_1 + IE_1\right] \quad (30)$$

$$\pi_2 = \frac{1}{T}\left[SR - OC - SrC - HC - DC - IP_2 + IE_1\right] \quad (31)$$

$$\pi_3 = \frac{1}{T}\left[SR - OC - SrC - HC - DC - IP_3 + IE_1\right] \quad (32)$$

$$\pi_4 = \frac{1}{T}\left[SR - OC - SrC - HC - DC - IP_4 + IE_2\right] \quad (33)$$

The optimal value of T* which maximizes π_i can be obtained by solving equation (30), (31), (32) and (33) by differentiating it with respect to T and equate it to zero

$$\text{i.e. } \frac{\partial \pi_i(T)}{\partial T} = 0, \quad i=1,2,3,4 \quad (34)$$

provided it satisfies the condition

$$\frac{d^2\pi_i}{dT^2} < 0, \quad i=1,2,3,4. \quad (35)$$

IV. NUMERICAL EXAMPLE

Case I: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, p= Rs. 40, p_d = 15, d= 0.02, z=0.40, λ= 10000, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, v_2 = 0.50, R = 0.06, Ie = 0.12, Ip=0.15, M = 0.04 in appropriate units. The optimal value of T* =0.1870, Profit*= Rs. 18959.4365 and optimum order quantity Q* = 93.6196.

Case II: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, p= Rs. 40, p_d = 15, d= 0.02, z=0.40, λ= 10000, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, v_2 = 0.50, R = 0.06, Ie = 0.12, Ip=0.15, M = 0.07 in appropriate units. The optimal value of T* =0.1859, Profit*= Rs. 19019.5999 and optimum order quantity Q* = 93.0681.

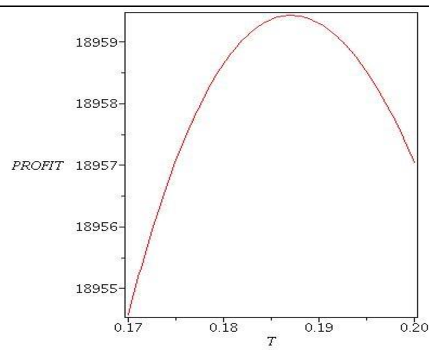
Case III: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, p= Rs. 40, p_d = 15, d= 0.02, z=0.40, λ= 10000, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, v_2 = 0.50, R = 0.06, Ie = 0.12, Ip=0.15, M = 0.15 in appropriate units. The optimal value of T* =0.1815, Profit*= Rs. 19193.6138 and optimum order quantity Q* = 90.8623.

Case IV: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, p= Rs. 40, p_d = 15, d= 0.02, z = 0.40, λ= 10000, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, v_2 = 0.50, R = 0.06, Ie = 0.12, Ip = 0.15, M = 0.22 in appropriate units. The optimal value of T* =0.1784, Profit*= Rs. 19359.6122 and optimum order quantity Q* = 89.3083.

The second order conditions given in equation (35) are also satisfied. The graphical representation of the concavity of the profit function is also given.

Case I

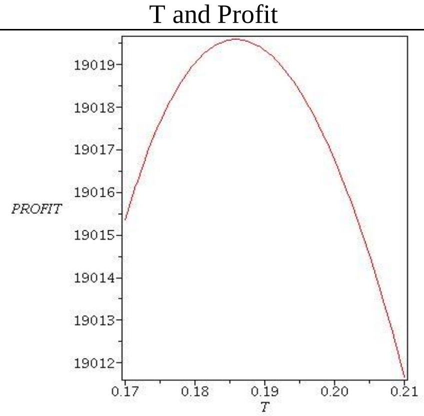
T and Profit



Graph 1

Case II

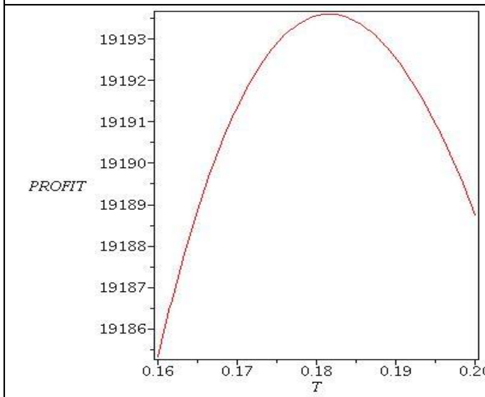
T and Profit



Graph 2

Case III

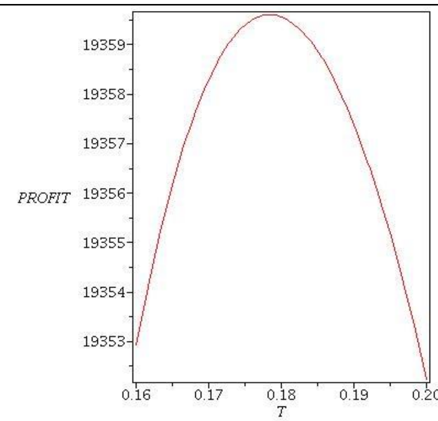
T and Profit



Graph 3

Case IV

T and Profit



Graph 4

V. SENSITIVITY ANALYSIS

On the basis of the data given in example above we have studied the sensitivity analysis by changing the following parameters one at a time and keeping the rest fixed.

Table 1
Case – I
Sensitivity Analysis

Para meter	%	T	Profit	Q
a	+20%	0.1706	22863.0081	102.4781
	+10%	0.1783	20910.0586	98.1839
	-10%	0.1972	17011.4996	88.8605
	-20%	0.2092	15066.7085	83.8016
x	+20%	0.1794	18914.2236	89.8096
	+10%	0.1831	18936.5699	91.6644
	-10%	0.1912	18982.7737	95.7253
	-20%	0.1956	19006.6420	97.9315
	+20%	0.1863	18956.1992	93.2922
	+10%	0.1867	18957.8164	93.4811

θ	-10%	0.1873	18961.0595	93.7581
	-20%	0.1897	18962.6853	93.9466
A	+20%	0.2049	18857.3815	102.5952
	+10%	0.1962	18907.2453	98.2324
	-10%	0.1774	19014.3160	88.8070
	-20%	0.1672	19072.3486	83.6944
λ	+20%	0.1870	18959.5146	93.6196
	+10%	0.1870	18959.4791	93.6196
	-10%	0.1870	18959.3844	93.6196
	-20%	0.1870	18959.3194	93.6196
R	+20%	0.1833	18937.5129	91.7646
	+10%	0.1851	18948.4206	92.6671
	-10%	0.1889	18970.5637	94.5722
	-20%	0.1909	18981.8057	95.5750
M	+20%	0.1868	18975.1024	93.5194
	+10%	0.1869	18967.2479	93.5695
	-10%	0.1871	18951.6682	93.6697
	-20%	0.1871	18943.9431	93.6697

Table 2
Case – II
Sensitivity Analysis

Para meter	%	T	Profit	Q
a	+20%	0.1694	22935.9459	101.7564
	+10%	0.1771	20976.5903	97.5222
	-10%	0.1960	17065.3367	88.3190
	-20%	0.2080	15114.2579	83.3201
x	+20%	0.1783	18974.6619	88.2556
	+10%	0.1820	18996.8997	91.1129
	-10%	0.1900	19042.7924	95.1237
	-20%	0.1944	19066.5107	97.3299
θ	+20%	0.1852	19016.3979	92.7405
	+10%	0.1855	19017.9975	92.8793
	-10%	0.1862	19021.2050	93.2067
	-20%	0.1865	19022.8130	93.3453
A	+20%	0.2038	18916.9497	102.0435
	+10%	0.1950	18967.0951	97.6307
	-10%	0.1762	19074.8331	88.2055
	-20%	0.1660	19133.2713	83.0930
λ	+20%	0.1859	19019.6775	93.0681
	+10%	0.1859	19019.6422	93.0681
	-10%	0.1858	19019.5481	93.0180
	-20%	0.1858	19019.4835	93.0180
R	+20%	0.1822	18997.7687	91.2132
	+10%	0.1840	19008.6307	92.1156
	-10%	0.1878	19030.6793	94.0207
	-20%	0.1898	19041.8722	95.0234
M	+20%	0.1853	19048.7788	92.7673
	+10%	0.1856	19034.1238	92.9177
	-10%	0.1861	19005.2065	93.1684
	-20%	0.1863	18990.9432	93.2687

Table 3
Case – III
Sensitivity Analysis

Para meter	%	T	Profit	Q
a	+20%	0.1646	23147.7306	98.8695
	+10%	0.1725	21169.3920	94.9859
	-10%	0.1919	17220.7636	86.4688
	-20%	0.2042	15251.3138	81.7955
	+20%	0.1742	19149.7227	87.2030
	+10%	0.1777	19171.4422	88.9574
x	-10%	0.1856	19216.2668	92.9177
	-20%	0.1899	19239.4340	95.0735
θ	+20%	0.1809	19190.5013	90.5837
	+10%	0.1812	19192.0562	90.7230
	-10%	0.1818	19195.1740	91.0015
	-20%	0.1821	19196.7369	91.1406
A	+20%	0.1998	19088.7389	100.0376
	+10%	0.1909	19139.9170	95.5750
	-10%	0.1716	19250.2429	85.8998
	-20%	0.1611	19310.3457	80.6373
λ	+20%	0.1815	19193.6896	90.8623
	+10%	0.1815	19193.6551	90.8623
	-10%	0.1815	19193.5633	90.8623
	-20%	0.1815	19193.5000	90.8623
R	+20%	0.1779	19172.0499	89.0576
	+10%	0.1797	19182.7796	89.9600
	-10%	0.1834	19204.5556	91.8148
	-20%	0.1853	19215.6082	92.7673
M	+20%	0.1790	19263.5796	89.6090
	+10%	0.1803	19228.2637	90.2607
	-10%	0.1826	19159.6171	91.4137
	-20%	0.1835	19126.2628	91.8649

Table 4
Case – IV
Sensitivity Analysis

Para meter	%	T	Profit	Q
a	+20%	0.1629	23348.5987	97.8472
	+10%	0.1701	21352.8950	93.6626
	-10%	0.1880	17369.1244	84.7090
	-20%	0.1993	15381.9131	79.8297
x	+20%	0.1718	19316.3978	86.0000
	+10%	0.1750	19337.8026	87.6040
	-10%	0.1820	19381.8503	91.1129
	-20%	0.1858	19404.5430	93.0180
θ	+20%	0.1778	19356.5598	89.0289
	+10%	0.1781	19358.0849	89.1686
	-10%	0.1786	19361.1418	89.3977
	-20%	0.1789	19362.6738	89.5373
A	+20%	0.1953	19252.5804	97.7811
	+10%	0.1870	19304.8844	93.6196
	-10%	0.1693	19417.1377	84.7470
	-20%	0.1596	19477.9425	79.8856
λ	+20%	0.1784	19359.6867	89.3083
	+10%	0.1784	19359.6528	89.3083
	-10%	0.1784	19359.5625	89.3083
	-20%	0.1784	19359.5005	89.3083
R	+20%	0.1750	19338.2763	87.6040
	+10%	0.1767	19348.8936	88.4561
	-10%	0.1801	19370.4350	90.1605
	-20%	0.1819	19381.3652	91.0628
M	+20%	0.1784	19465.2141	89.3083
	+10%	0.1784	19412.4131	89.3083
	-10%	0.1784	19306.8112	89.3083
	-20%	0.1784	19254.0103	89.3083

From the table we observe that as parameter a increases/ decreases average total profit and optimum order quantity also increases/ decreases for all the four cases.

Also, we observe that with increase and decrease in the value of x and R, there is corresponding decrease/ increase in total profit and optimum order quantity for all the four cases.

Also, we observe that with increase and decrease in the value of θ, there is corresponding decrease/ increase in total profit and almost no change in optimum order quantity for all the four cases.

From the table we observe that as parameter A increases/ decreases average total profit decreases/ increases and optimum order quantity increases/ decreases for all the four cases.

From the table we observe that as parameter λ increases/ decreases there is very minor change in average total profit and no change in optimum order quantity for all the four cases.

From the table we observe that as parameter M increases/ decreases average total profit increases/ decreases for all the four cases and optimum order quantity decreases/ increases for first three cases and there is no change in optimum order quantity for case IV.

VI. CONCLUSION

In this paper, we have developed an inventory model for deteriorating items with linear demand with different deterioration rates with inflation and permissible delay in payments. Sensitivity with respect to parameters have been carried out. The results show that with the increase/ decrease in the parameter values there is corresponding increase/ decrease in the value of profit.

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