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Inventory Model with Different Deterioration Rates with Time and Price Dependent Demand under Inflation and Permissible Delay in Payments

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Abstract

An inventory model for deteriorating items with stock and price dependent demand is developed. Holding cost is considered as function of time. Shortages are not allowed. Numerical example is provided to illustrate the model and sensitivity analysis is also carried out for parameters.

Keywords: Inventory model, Deterioration, Price dependent demand, Time dependent demand, Time varying holding cost

1. INTRODUCTION:

In real life, deterioration of items is a general phenomenon for many inventory systems and therefore deterioration effect cannot be ignored. Many researchers have studied EOQ models for deteriorating items in past. Ghare and Schrader [2] considered no-shortage inventory model with constant rate of deterioration. The model was extended by Covert and Philip [1] by considering variable rate of deterioration. By considering shortages, the model was further extended by Shah and Jaiswal [14]. The related work are found in (Nahmias [9], Raffat [12], Goyal and Giri [3], Ouyang et al. [10], Wu et al. [16]).

Hill [4] considered inventory model with ramp type demand rate. Mandal and Pal [6] developed inventory model with ramp type demand with shortages. Hung [5] considered inventory model with arbitrary demand and arbitrary deterioration rate.

Salameh and Jaber [13] developed a model to determine the total profit per unit of time and the economic order quantity for a product purchased from the supplier. Mukhopadhyay et al. [8] developed an inventory model for deteriorating items with a price-dependent demand rate. The rate of deterioration was taken to be time-proportional and a power law form of the price-dependence of demand was considered. Teng and Chang [15] considered the economic production quantity model for deteriorating items with stock level and selling price dependent demand. Mathew [7] developed an inventory model for deteriorating items with mixture of Weibull rate of decay and demand as function of both selling price and time. Patel and Parekh [11] developed an inventory model with stock dependent demand under shortages and variable selling price.

Inventory models for non-instantaneous deteriorating items have been an object of study for a long time. Generally the products are such that there is no deterioration initially. After certain time deterioration starts 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 with stock and price dependent demand with different deterioration rates for the cycle time. Shortages are not allowed. To illustrate the model, numerical example is taken and sensitivity analysis for major parameters on the optimal solutions is also carried out.

2. ASSUMPTIONS AND NOTATIONS:

NOTATIONS:

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

D(t) : Demand rate is a linear function of price and inventory level ($a + bt - \rho p$, $a>0$, $0<b<1$, $\rho>0$)

A : Replenishment cost per order

c : Purchasing cost per unit

p : Selling price per unit

h(t) : $x+yt$ ($x>0$, $0<y<1$), Inventory variable holding cost per unit excluding interest charges

M : Permissible period of delay in settling the accounts with the supplier

T : Length of inventory cycle

I_e : Interest earned per year

I_p : Interest paid in stocks per year

R : Inflation rate

I(t) : Inventory level at any instant of time t, $0 \leq t \leq T$

Q : Order quantity

θ : Deterioration rate during $\mu_1 \leq t \leq \mu_2$, $0< \theta <1$

θt : Deterioration rate during , $\mu_2 \leq t \leq T$, $0< \theta <1$

π : Total relevant profit per unit time.

ASSUMPTIONS:

The following assumptions are considered for the development of the model.

- The demand of the product is declining as a function of price and time.
- Replenishment rate is infinite and instantaneous.
- Lead time is zero.
- Shortages are not allowed.
- Deteriorated units neither be repaired nor replaced during the cycle time.
- 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.

3. THE MATHEMATICAL MODEL AND ANALYSIS:

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

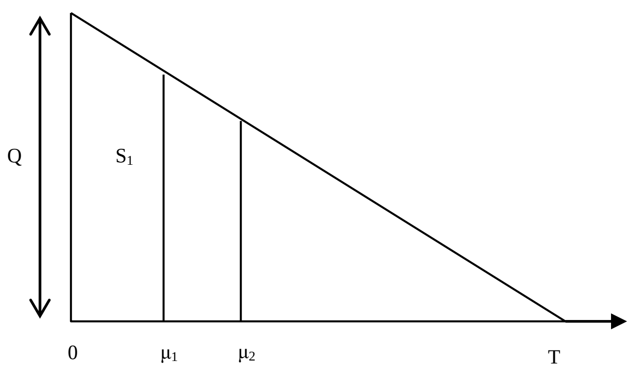

Figure 1

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

$$\frac{dI(t)}{dt} = -(a + bt - \rho p), \qquad 0 \le t \le \mu_1 \tag{1}$$

$$\frac{dI(t)}{dt} + \theta I(t) = -(a + bt - \rho p), \qquad \mu_1 \le t \le \mu_2 \tag{2}$$

$$\frac{dI(t)}{dt} + \theta t I(t) = -(a + bt - \rho p), \qquad \mu_2 \le t \le T \tag{3}$$

with initial conditions $I(0) = Q$, $I(\mu_1) = S_1$, $I(T) = 0$.

Solutions of these equations are given by

$$I(t) = Q - (at - \rho pt + \frac{1}{2}bt^2), \tag{4}$$

$$I(t) = \left[\begin{array}{l} a(\mu_1 - t) - \rho p(\mu_1 - t) + \frac{1}{2}a\theta(\mu_1^2 - t^2) - \frac{1}{2}\rho p\theta(\mu_1^2 - t^2) + \frac{1}{2}b(\mu_1^2 - t^2) \\ + \frac{1}{3}b\theta(\mu_1^3 - t^3) - a\theta t(\mu_1 - t) + \rho p\theta t(\mu_1 - t) - \frac{1}{2}b\theta t(\mu_1^2 - t^2) \end{array}\right] + S_1\left[1 + (\theta + b)(\mu_1 - t)\right] \tag{5}$$

$$I(t) = \left[\begin{array}{l} a(T - t) - \rho p(T - t) + \frac{1}{2}b(T^2 - t^2) + \frac{1}{6}a\theta(T^3 - t^3) - \frac{1}{6}\rho p\theta(T^3 - t^3) \\ + \frac{1}{8}b\theta(T^4 - t^4) - \frac{1}{2}a\theta t^2(T - t) + \frac{1}{2}\rho p\theta t^2(T - t) - \frac{1}{4}b\theta t^2(T^2 - t^2) \end{array}\right] \tag{6}$$

(by neglecting higher powers of θ)

From equation (4), putting $t = \mu_1$, we have

$$Q = S_1 + \left(a\mu_1 - \rho p\mu_1 + \frac{1}{2}b\mu_1^2\right). \tag{7}$$

From equations (5) and (6), putting $t = \mu_2$, we have

$$I(\mu_2) = \left[\begin{array}{l} a(\mu_1 - \mu_2) - \rho p(\mu_1 - \mu_2) + \frac{1}{2}a\theta(\mu_1^2 - \mu_2^2) - \frac{1}{2}\rho p\theta(\mu_1^2 - \mu_2^2) + \frac{1}{2}b(\mu_1^2 - \mu_2^2) \\ + \frac{1}{3}b\theta(\mu_1^3 - \mu_2^3) - a\theta\mu_2(\mu_1 - \mu_2) + \rho p\theta\mu_2(\mu_1 - \mu_2) - \frac{1}{2}b\theta t(\mu_1^2 - \mu_2^2) \end{array}\right] + S_1\left[1 + (\theta+b)(\mu_1 - \mu_2)\right] \quad (8)$$

$$I(\mu_2) = \left[\begin{array}{l} a(T - \mu_2) - \rho p(T - \mu_2) + \frac{1}{2}b(T^2 - \mu_2^2) + \frac{1}{6}a\theta(T^3 - \mu_2^3) - \frac{1}{6}\rho p\theta(T^3 - \mu_2^3) \\ + \frac{1}{8}b\theta(T^4 - \mu_2^4) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) + \frac{1}{2}\rho p\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta\mu_2^2(T^2 - \mu_2^2) \end{array}\right]. \quad (9)$$

So from equations (8) and (9), we get

$$S_1 = \frac{1}{\left[1 + (\theta+b)(\mu_1 - \mu_2)\right]} \left[\begin{array}{l} a(T - \mu_2) - \rho p(T - \mu_2) + \frac{1}{2}b(T^2 - \mu_2^2) + \frac{1}{6}a\theta(T^3 - \mu_2^3) - \frac{1}{6}\rho p\theta(T^3 - \mu_2^3) \\ + \frac{1}{8}b\theta(T^4 - \mu_2^4) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) + \frac{1}{2}\rho p\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta\mu_2^2(T^2 - \mu_2^2) \\ - a(\mu_1 - \mu_2) + \rho p(\mu_1 - \mu_2) - \frac{1}{2}a\theta(\mu_1^2 - \mu_2^2) + \frac{1}{2}\rho p\theta(\mu_1^2 - \mu_2^2) - \frac{1}{2}b(\mu_1^2 - \mu_2^2) \\ - \frac{1}{3}b\theta(\mu_1^3 - \mu_2^3) + a\theta\mu_2(\mu_1 - \mu_2) - \rho p\theta\mu_2(\mu_1 - \mu_2) + \frac{1}{2}b\theta\mu_2(\mu_1^2 - \mu_2^2) \end{array}\right]. \quad (10)$$

Putting value of S_1 from equation (10) into equation (5), we have

$$I(t) = \frac{\left\lfloor 1 + (\theta+b)(\mu_1 - t)\right\rfloor}{\left[1 + (\theta+b)(\mu_1 - \mu_2)\right]} \left[\begin{array}{l} a(T - \mu_2) - \rho p(T - \mu_2) + \frac{1}{2}b(T^2 - \mu_2^2) + \frac{1}{6}a\theta(T^3 - \mu_2^3) - \frac{1}{6}\rho p\theta(T^3 - \mu_2^3) \\ + \frac{1}{8}b\theta(T^4 - \mu_2^4) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) + \frac{1}{2}\rho p\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta\mu_2^2(T^2 - \mu_2^2) \\ - a(\mu_1 - \mu_2) + \rho p(\mu_1 - \mu_2) - \frac{1}{2}a\theta(\mu_1^2 - \mu_2^2) + \frac{1}{2}\rho p\theta(\mu_1^2 - \mu_2^2) - \frac{1}{2}b(\mu_1^2 - \mu_2^2) \\ - \frac{1}{3}b\theta(\mu_1^3 - \mu_2^3) + a\theta\mu_2(\mu_1 - \mu_2) - \rho p\theta\mu_2(\mu_1 - \mu_2) + \frac{1}{2}b\theta\mu_2(\mu_1^2 - \mu_2^2) \end{array}\right] \quad (11)$$

$$+ \left[\begin{array}{l} a(\mu_1 - t) - \rho p(\mu_1 - t) + \frac{1}{2}a\theta(\mu_1^2 - t^2) - \frac{1}{2}\rho p\theta(\mu_1^2 - t^2) + \frac{1}{2}b(\mu_1^2 - t^2) \\ + \frac{1}{3}b\theta(\mu_1^3 - t^3) - a\theta t(\mu_1 - t) + \rho p\theta t(\mu_1 - t) - \frac{1}{2}b\theta t(\mu_1^2 - t^2) \end{array}\right].$$

Similarly, putting value of S_1 from equation (10) into equation (7), we have

$$Q = \frac{1}{\left[1+(\theta+b)(\mu_1-\mu_2)\right]}\left[\begin{array}{l} a(T-\mu_2)-\rho p(T-\mu_2)+\frac{1}{2}b(T^2-\mu_2^2)+\frac{1}{6}a\theta(T^3-\mu_2^3)-\frac{1}{6}\rho p\theta(T^3-\mu_2^3) \\ +\frac{1}{8}b\theta(T^4-\mu_2^4)-\frac{1}{2}a\theta\mu_2^2(T-\mu_2)+\frac{1}{2}\rho p\theta\mu_2^2(T-\mu_2)-\frac{1}{4}b\theta\mu_2^2(T^2-\mu_2^2) \\ -a(\mu_1-\mu_2)+\rho p(\mu_1-\mu_2)-\frac{1}{2}a\theta(\mu_1^2-\mu_2^2)+\frac{1}{2}\rho p\theta(\mu_1^2-\mu_2^2)-\frac{1}{2}b(\mu_1^2-\mu_2^2) \\ -\frac{1}{3}b\theta(\mu_1^3-\mu_2^3)+a\theta\mu_2(\mu_1-\mu_2)-\rho p\theta\mu_2(\mu_1-\mu_2)+\frac{1}{2}b\theta\mu_2(\mu_1^2-\mu_2^2) \end{array}\right] + \left(a\mu_1-\rho p\mu_1+\frac{1}{2}b\mu_1^2\right). \tag{12}$$

Putting value of Q in equation (4), we get

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

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

(i) Ordering cost (OC) = A (14)

(ii) $HC = \int_0^T (x+yt)I(t)e^{-Rt}dt = \int_0^{\mu_1}(x+yt)I(t)e^{-Rt}dt + \int_{\mu_1}^{\mu_2}(x+yt)I(t)e^{-Rt}dt + \int_{\mu_2}^{T}(x+yt)I(t)e^{-Rt}dt$ (15)

(iii) $DC = c\left(\int_{\mu_1}^{\mu_2}\theta I(t)e^{-Rt}dt + \int_{\mu_2}^{T}\theta tI(t)e^{-Rt}dt\right)$ (16)

(iv) $SR = p\left(\int_0^T (a+bt - \rho p)e^{-Rt}dt\right)$ (17)

(by neglecting higher powers of θ)

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.

(v) Interest earned per cycle:

$$IE_1 = pI_e\int_0^M (a + bt - \rho p)\,te^{-Rt}dt \tag{18}$$

Case II: (0 ≤T ≤ M):

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

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

$$IE_2 = p\,I_e\left[\int_0^T (a + bt - \rho p)\,t\,e^{-Rt}dt + (a + bT - \rho p)T(M - T)\right] \tag{19}$$

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≤μ1):

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

$$= cI_p\left(\int_M^{\mu_1} I(t)e^{-Rt}dt + \int_{\mu_1}^{\mu_2} I(t)e^{-Rt}dt + \int_{\mu_2}^{T} I(t)e^{-Rt}dt\right) \tag{20}$$

Case II: (μ1≤M≤ μ2):

(viii) $IP_2 = cI_p\int_M^T I(t)e^{-Rt}dt = cI_p\left(\int_M^{\mu_2} I(t)e^{-Rt}dt + \int_{\mu_2}^{T} I(t)e^{-Rt}dt\right)$ (21)

Case III: ($\mu_2 \le M \le T$):

(ix) $IP_3 = cI_p \int_M^T I(t)e^{-Rt}dt$ (22)

Case IV: ($T \le M \le T$):

(x) $IP_4 = 0$ (23)

(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:

$$\pi_i = \frac{1}{T}\left[SR - OC - HC - DC - SC - IP_i + IE_i\right] \quad (24)$$

Substituting values from equations (14) to (23) in equation (24), we get total profit per unit. Putting $\mu_1 = v_1T$, $\mu_2 = v_2T$ in equation (24), we get profit in terms of T and p for the four cases will be as under:

$$\pi_1 = \frac{1}{T}\left[SR - OC - HC - DC - SC - IP_1 + IE_1\right] \quad (25)$$

$$\pi_2 = \frac{1}{T}\left[SR - OC - HC - DC - SC - IP_2 + IE_1\right] \quad (26)$$

$$\pi_3 = \frac{1}{T}\left[SR - OC - HC - DC - SC - IP_3 + IE_1\right] \quad (27)$$

$$\pi_4 = \frac{1}{T}\left[SR - OC - HC - DC - SC - IP_4 + IE_2\right] \quad (28)$$

The optimal value of T* and p* (say), which maximizes π_i can be obtained by solving equation (25), (26), (27) and (28) by differentiating it with respect to T and p and equate it to zero

$$\text{i.e. } \frac{\partial \pi_i(T,p)}{\partial T} = 0, \ \frac{\partial \pi_i(T,p)}{\partial p} = 0, \quad i=1,2,3,4 \quad (29)$$

provided it satisfies the condition

$$\begin{vmatrix} \frac{\partial \pi_i^2(T,p)}{\partial T^2} & \frac{\partial \pi_i^2(T,p)}{\partial T \partial p} \\ \frac{\partial \pi_i^2(T,p)}{\partial p \partial T} & \frac{\partial \pi_i^2(T,p)}{\partial p^2} \end{vmatrix} > 0 \quad i=1,2,3,4. \tag{30}$$

4. NUMERICAL EXAMPLE:

Case I: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, ρ= 5, 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 = 0.06 in appropriate units. The optimal value of T*=0.2568, p* = 50.4873, Profit*= Rs. 11784.6608 and Q*=63.7164.

Case II: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, ρ= 5, 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 = 0.10 in appropriate units. The optimal value of T*=0.2544, p* = 50.4296, Profit*= Rs. 11828.8103 and Q*=63.1617.

Case III: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, ρ= 5, 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 = 0.20 in appropriate units. The optimal value of T*=0.2430, p* = 50.3310, Profit*= Rs. 11955.0658 and Q*=60.4524.

Case IV: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, ρ= 5, 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 = 0.28 in appropriate units. The optimal value of T*=0.2353, p* = 50.3107, Profit*= Rs. 12072.5092 and Q*=58.5820.

The second order conditions given in equation (30) are also satisfied. The graphical representation of the concavity of the profit function is also given.

<table>
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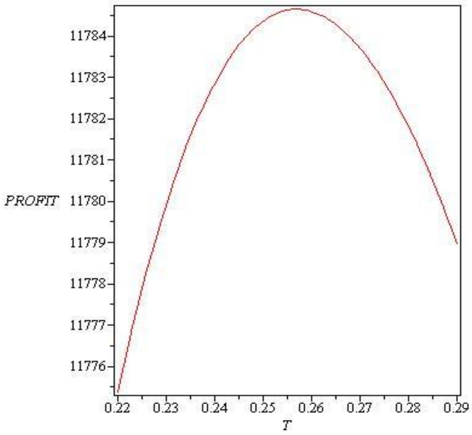
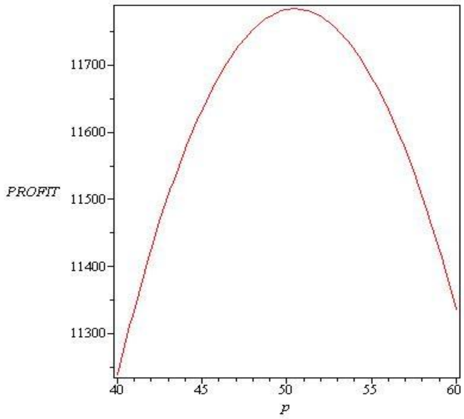
<tr><td>T and Profit</td><td>p and Profit</td></tr>
<tr><td>

Graph 1</td><td>

Graph 2</td></tr>
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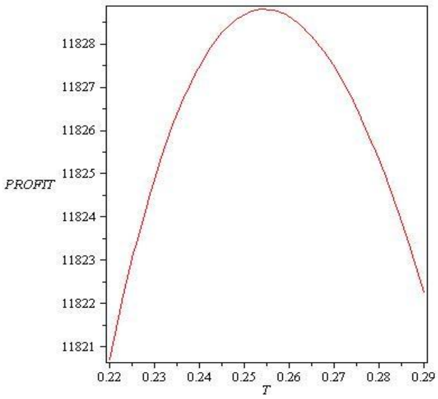
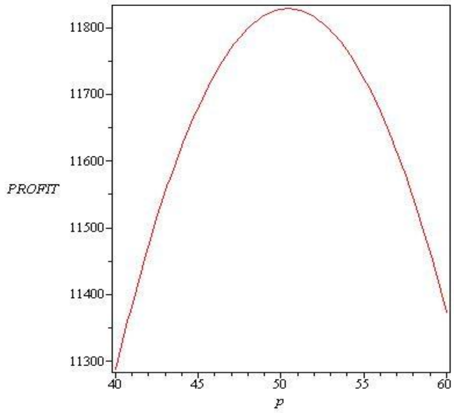
<tr><td>

Graph 3</td><td>

Graph 4</td></tr>
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<table>
<tr><td colspan="2">Case III</td></tr>
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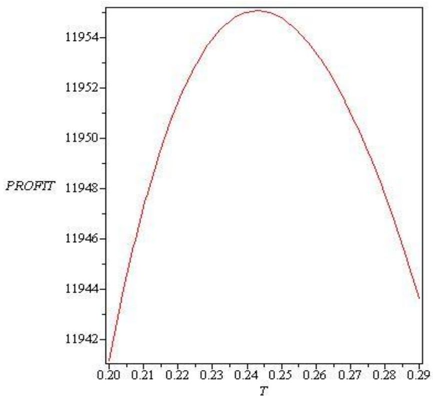
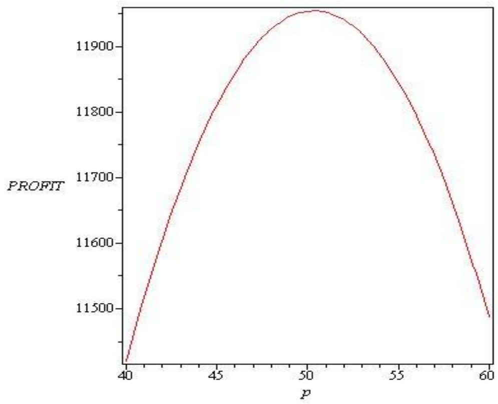
<tr><td>

Graph 5</td><td>

Graph 6</td></tr>
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<table>
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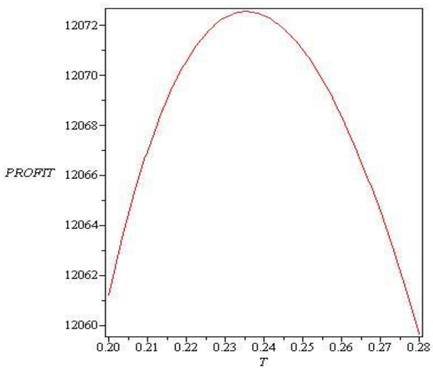
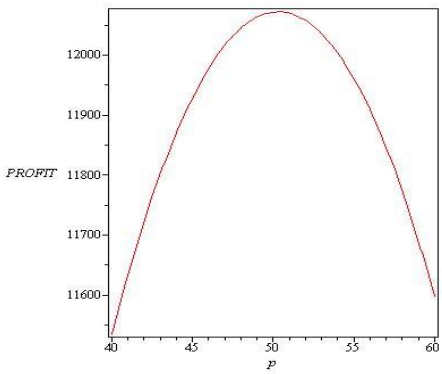
<tr><td>

Graph 7</td><td>

Graph 8</td></tr>
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5. 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 ($0 \le M \le \mu_1$)

Sensitivity Analysis

Parameter	%	T	p	Profit	Q
a	+20%	0.2277	60.4217	17204.8853	67.9387
	+10%	0.2413	55.4523	14369.0889	65.9248
	-10%	0.2748	45.5280	9451.7568	61.2267
	-20%	0.2960	40.5761	7370.5953	58.4748
θ	+20%	0.2559	50.4900	11782.3570	63.4875
	+10%	0.2564	50.4886	11783.5079	63.6021
	-10%	0.2573	50.4860	11785.8159	63.8060
	-20%	0.2578	50.4847	11786.9731	63.9202
x	+20%	0.2470	50.5271	11753.6060	61.2069
	+10%	0.2518	50.5075	11768.9794	62.4235
	-10%	0.2622	50.4666	11800.6694	65.0611
	-20%	0.2679	50.4452	11817.0261	66.5073
A	+20%	0.2816	50.5435	11710.3851	69.7778
	+10%	0.2695	50.5160	11746.6680	66.8098
	-10%	0.2435	50.4572	11824.6303	60.4231
	-20%	0.2294	50.4256	11866.9206	56.9541
M	+20%	0.2562	50.4690	11797.5363	63.5660
	+10%	0.2565	50.4780	11791.0589	63.6290
	-10%	0.2571	50.4968	11778.3419	63.7540
	-20%	0.2573	50.5065	11772.1021	63.7912
ρ	+20%	0.2632	42.1682	9716.0384	65.1314
	+10%	0.2602	45.9495	10656.2546	64.4623
	-10%	0.2529	56.0340	13164.0240	62.7942
	-20%	0.2482	62.9679	14888.5123	61.6948
R	+20%	0.2508	50.4739	11765.8978	62.2173
	+10%	0.2538	50.4805	11775.2247	62.9547
	-10%	0.2600	50.4944	11794.2101	64.4778
	-20%	0.2633	50.5017	11803.8765	65.2883

Table 2

Case II ($\mu_1 \le M \le \mu_2$)

Sensitivity Analysis

Parameter	%	T	p	Profit	Q
a	+20%	0.2238	60.3640	17264.1310	66.8377
	+10%	0.2382	55.3946	14420.3950	65.1450
	-10%	0.2731	45.4700	9489.4564	60.9264
	-20%	0.2948	40.5178	7402.4778	58.3233
θ	+20%	0.2535	50.4322	11826.5412	62.9640
	+10%	0.2540	50.4309	11827.6747	63.0789
	-10%	0.2549	50.4282	11829.9479	63.2834
	-20%	0.2553	50.4269	11831.0875	63.3732
x	+20%	0.2447	50.4698	11798.0128	60.7060
	+10%	0.2494	50.4500	11813.2586	61.8991
	-10%	0.2597	50.4086	11844.6867	64.5148
	-20%	0.2654	50.3869	11860.9088	65.9628
A	+20%	0.2794	50.4839	11753.8854	69.3184
	+10%	0.2672	50.4573	11790.4713	66.3170
	-10%	0.2410	50.4006	11869.1812	59.8698
	-20%	0.2267	50.3702	11911.9454	56.3454
M	+20%	0.2528	50.4044	11852.2089	62.8025
	+10%	0.2536	50.4167	11840.3981	62.9860
	-10%	0.2551	50.4431	11817.4435	63.3256
	-20%	0.2558	50.4572	11806.2964	63.4817
ρ	+20%	0.2617	42.1119	9756.9162	64.8480
	+10%	0.2583	45.8925	10698.6026	64.0717
	-10%	0.2498	55.9752	13210.4316	62.0891
	-20%	0.2443	62.9080	14937.8318	60.7821
R	+20%	0.2484	50.4169	11810.1784	61.6916
	+10%	0.2514	50.4231	11819.4403	62.4304
	-10%	0.2575	50.4363	11838.2921	63.9314
	-20%	0.2608	50.4432	11847.8900	64.7435

Table 3

Case III ($\mu_2 \le M \le T$)

Sensitivity Analysis

Parameter	%	T	p	Profit	Q
a	+20%	0.2046	60.2718	17447.2483	61.1888
	+10%	0.2230	55.2990	14572.8828	61.0873
	-10%	0.2650	45.3688	9593.2640	59.2921
	-20%	0.2898	40.4138	7487.0984	57.4826
θ	+20%	0.2422	50.3339	11952.9158	60.2700
	+10%	0.2426	50.3325	11953.9899	60.3612
	-10%	0.2434	50.3295	11956.1436	60.5435
	-20%	0.2438	50.3280	11957.2232	60.6347
x	+20%	0.2336	50.3738	11925.5901	58.0594
	+10%	0.2382	50.3527	11940.1809	59.2062
	-10%	0.2481	50.3087	11970.2629	61.7514
	-20%	0.2536	50.2858	11985.7925	63.1523
A	+20%	0.2690	503759	11876.9494	66.874
	+10%	0.2563	503536	11915.0159	63.7390
	-10%	0.2289	50.3081	11997.4448	56.9644
	-20%	0.2139	50.2851	12042.6131	53.2498
M	+20%	0.2361	50.3133	12012.4391	58.7534
	+10%	0.2397	50.3204	11983.2280	59.6425
	-10%	0.2459	50.3449	11927.9130	61.1582
	-20%	0.2485	50.3619	11901.7366	61.7849
ρ	+20%	0.2551	42.0181	9867.4442	63.3529
	+10%	0.2496	45.7965	10816.1417	62.0412
	-10%	0.2352	55.8737	13347.8053	58.5608
	-20%	0.2256	62.8030	15089.8533	56.2151
R	+20%	0.2373	50.3218	11937.0191	59.0426
	+10%	0.2401	50.3263	11945.9911	59.7352
	-10%	0.2460	50.3359	11964.2466	61.1942
	-20%	0.2491	50.3411	11973.5375	61.9604

Table 4

Case I (M>T)

Sensitivity Analysis

Parameter	%	T	p	Profit	Q
a	+20%	0.2026	60.2664	17619.9264	60.5952
	+10%	0.2177	55.2868	14716.8952	59.6462
	-10%	0.2562	45.3391	9686.8338	57.3161
	-20%	0.2813	40.3734	7559.9631	55.8495
θ	+20%	0.2347	50.3138	12070.4928	58.4230
	+10%	0.2351	50.3122	15071.5288	58.5151
	-10%	0.2357	50.3092	12073.6050	58.6491
	-20%	0.2360	50.3074	12074.6453	58.7161
x	+20%	0.2278	50.3564	12043.9074	56.6351
	+10%	0.2315	50.3338	12058.1167	57.5829
	-10%	0.2394	50.2866	12087.2683	59.6083
	-20%	0.2438	50.2619	12102.2367	60.7362
A	+20%	0.2577	50.3411	11991.3864	64.1041
	+10%	0.2468	50.3261	12031.0922	61.4057
	-10%	0.2234	50.2943	12116.1599	55.6087
	-20%	0.2106	50.2772	12162.2380	52.4352
M	+20%	0.2354	50.3085	12159.5670	58.5864
	+10%	0.2354	50.3096	12114.5666	58.5833
	-10%	0.2354	50.3116	12030.5658	58.5809
	-20%	0.2354	50.3127	11988.5655	58.5797
ρ	+20%	0.2488	41.9954	9964.9392	61.8191
	+10%	0.2424	45.7746	10922.6288	60.2772
	-10%	0.2276	55.8556	13479.0010	56.6836
	-20%	0.2188	62.7883	15238.3719	47.6519
R	+20%	0.2306	50.3042	12054.9153	57.3928
	+10%	0.2329	50.3074	12063.6947	57.9625
	-10%	0.2379	50.3140	12081.5327	59.2014
	-20%	0.2405	50.3174	12090.5973	59.8456

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

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.

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

Also, we observe that with increase and decrease in the value of M there is corresponding increase/ decrease in total profit for all the four case, whereas decrease/ increase in optimum order quantity for case I, II and III and increase/ decrease in optimum order quantity for case IV.

From the table we observe that as parameter θ increases/ decreases there is almost very little change in average total profit and optimum order quantity.

6. CONCLUSION:

In this paper, we have developed an inventory model for deteriorating items with price and inventory dependent demand with different deterioration rates. 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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