International Journal of Computational and Applied Mathematics.
ISSN 1819-4966 Volume 12, Number 2 (2017), pp. 425-439

http://www.ripublication.com

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

Raman Patel

Department of Statistics
Veer Narmad South Gujarat University
Surat, India.

Abstract

A production inventory model for deteriorating items with stock and price dependent demand under inflation and permissible delay in payments is developed. Different deterioration rates are considered in a cycle. 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: Production, Inventory model, Varying Deterioration, Time dependent demand, Price dependent demand, Permissible delay in payments, Inflation

2010 Mathematics Subject Classification: 90B05

1. INTRODUCTION:

Deterioration is an important factor for inventory system. The first production lot size model with constant and variable rate of deterioration was developed by Mishra [10]. An inventory model determining the production rate for deteriorating items to minimize the total cost function over a finite planning period was considered by Choi and Hwang [4]. Panda et al. [13] considered a single item economic production quantity model with ramp type quadratic demand. Manna and Chiang [9] developed an economic production quantity model for deteriorating item with ramp type demand.

An inventory model when demand for products is price and time dependent was developed by You [21]. Two production inventory models (Model I and Model II) for deteriorating items when the demand rate depends on the instantaneous inventory level was developed by Roy and Chaudhury [17]. Sahoo et al. [18] developed an inventory model for constant deteriorating items with price dependent demand and time varying holding cost. Patra et al. [16] considered a deterministic inventory model with price dependent quadratic demand rate. Patel and Patel [14] developed a deteriorating items production inventory model with demand dependent production rate.

Goyal [7] first considered the economic order quantity model under the condition of permissible delay in payments. Aggarwal and Jaggi [1] extended Goyal's [7] model to consider the deteriorating items. The related work are found in (Chung and Dye [5], Salameh et al. [19], Chung et al. [6], Chang et al. [3]).

The effect of inflation and time value of money play important role in practical situations. Buzacott [2] and Mishra [11] simultaneously developed inventory model with constant demand and single inflation rate for all associated costs. Mishra [12] considered different inflation rate for different costs associated with inventory model with constant rate of demand. An inventory model for stock dependent consumption and permissible delay in payment under inflationary conditions was developed by Liao et al. [8]. Singh [20] developed an EOQ model with linear demand and permissible delay in payments. The effect of inflation and time value of money were also taken into account. Patel and Patel [15] developed an inventory model with inflation and permissible delay in payments.

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 a production inventory model with different deterioration rates under inflation and permissible delay in payments. Demand of the product is price and time dependent. Shortages are not allowed. To illustrate the model numerical example is provided and sensitivity analysis of the optimal solutions for major parameters is also carried out.

2. ASSUMPTIONS AND NOTATIONS:

NOTATIONS:

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

P(t) : Production rate is a function of demand ($P(t) = \eta D(t)$, $\eta>1$)

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

SeC : Set-up 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

I_e : Interest earned per year

I_p : Interest paid in stocks per year

R : Inflation rate

T : Length of inventory cycle

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

Q : Inventory level at time t_1

θ : Deterioration rate during $\mu_1 \le t \le t_1$, $0< \theta<1$

θt : Deterioration rate during , $t_1 \le t \le T$, $0< \theta<1$

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 time and price.
- Rate of production is a function of demand
- 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 ($0 \le t \le T$) as shown in figure.

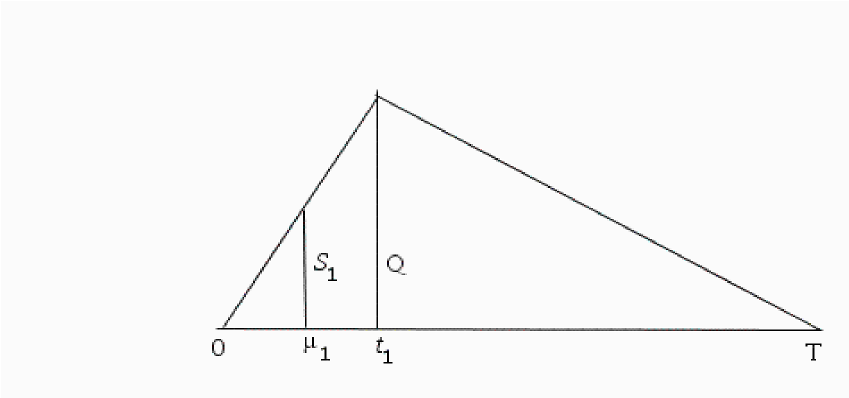


Figure 1

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

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

$$\frac{dI(t)}{dt} + \theta I(t) = (\eta - 1)(a + bt - \rho p), \qquad \mu_1 \le t \le t_1 \quad (2)$$

$$\frac{dI(t)}{dt} + \theta t I(t) = -(a + bt - \rho p), \qquad t_1 \le t \le T \quad (3)$$

with initial conditions I(0) = 0, $I(\mu_1) = S_1$, $I(t_1) = Q$ and I(T) = 0.

Solutions of these equations are given by

$$I(t) = (\eta - 1)\left((a - \rho p)t - \frac{1}{2}bt^2\right). \quad (4)$$

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

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

(by neglecting higher powers of θ)

Putting $t = \mu_1$ in equation (4), we get

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

Putting $t = t_1$ in equations (5) and (6), we have

$$I(t_1) = S_1\left[1 + \theta(\mu_1 - t_1)\right] - (\eta-1)\begin{bmatrix}(a - \rho p)(\mu_1 - t_1) + \frac{1}{2}b(\mu_1^2 - t_1^2) + \frac{1}{2}(a - \rho p)\theta(\mu_1^2 - t_1^2) \\ + \frac{1}{3}b\theta(\mu_1^3 - t_1^3) - (a - \rho p)\theta t_1(\mu_1 - t_1) - \frac{1}{2}b\theta t_1(\mu_1^2 - t_1^2)\end{bmatrix} \tag{8}$$

$$I(t_1) = \begin{bmatrix}(a - \rho p)(T - t_1) + \frac{1}{2}b(T^2 - t_1^2) + \frac{1}{6}(a - \rho p)\theta(T^3 - t_1^3) \\ + \frac{1}{8}b\theta(T^4 - t_1^4) - \frac{1}{2}(a - \rho p)\theta t_1^2(T - t_1) - \frac{1}{4}b\theta t_1^2(T^2 - t_1^2)\end{bmatrix}. \tag{9}$$

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

$$t_1 = \frac{\left[(a - \rho p)T - S_1(1+\theta\mu_1) + (\eta-1)(a - \rho p)\mu_1\right]}{(a - \rho p) - S_1\theta + (a - \rho p)(\eta-1) + (\eta-1)(a - \rho p)\theta\mu_1} \tag{10}$$

From equation (10), we see that t_1 is a function of μ_1, T and S_1, so t_1 is not a decision variable.

Putting value of S_1 from equation (7) in equation (5), we have

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

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

(i) Set up cost (SeC) = A (12)

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

$$= \int_0^{\mu_1} (x+yt)I(t)e^{-Rt}dt + \int_{\mu_1}^{t_1} (x+yt)I(t)e^{-Rt}dt + \int_{t_1}^{T} (x+yt)I(t)e^{-Rt}dt \tag{13}$$

(iii) $DC = c\left(\int_{\mu_1}^{t_1} \theta I(t)e^{-Rt}dt + \int_{t_1}^{T} \theta t I(t)e^{-Rt}dt\right)$ (14)

(iv) $SR = p\left(\int_{0}^{T} (a + bt - \rho p)e^{-Rt}dt\right)$ (15)

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

Case I: ($0 \le M \le T$) and Case II: ($0 \le T \le M$).

Case I: ($0 \le M \le T$): 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:

$$IE_1 = pI_e \int_{0}^{M} (a + bt - \rho p)\, t e^{-Rt}dt \tag{16}$$

Case II: ($0 \le T \le M$):

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:

$$IE_2 = p I_e \left[\int_{0}^{T} (a + bt - \rho p)\, t e^{-Rt}dt + (a + bT - \rho p)T(M - T)\right] \tag{17}$$

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

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

Case I: ($0 \le M \le \mu_1$):

(viii) $IP_1 = cI_p \int_{M}^{T} I(t)e^{-Rt}dt = cI_p\left(\int_{M}^{\mu_1} I(t)e^{-Rt}dt + \int_{\mu_1}^{t_1} I(t)e^{-Rt}dt + \int_{t_1}^{T} I(t)e^{-Rt}dt\right)$ (18)

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

(ix) $IP_2 = cI_p \int_{M}^{T} I(t)e^{-Rt}dt = cI_p\left(\int_{M}^{\mu_2} I(t)e^{-Rt}dt + \int_{\mu_2}^{T} I(t)e^{-Rt}dt\right)$ (19)

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

(x) $IP_3 = cI_p \int_{M}^{T} I(t)e^{-Rt}dt$ (20)

Case IV: (M>T):

(xi) $IP_4 = 0$ (21)

(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:

$$\pi_i = \frac{1}{T}\left[SR - SeC - HC - DC - SC - IP_i + IE_i\right] \quad (22)$$

Substituting values from equations (12) to (21) in equation (22), we get total profit per unit. Putting $\mu_1 = v_1 T$ in equation (22), we get profit in terms of T and p for the four cases will be as under:

$$\pi_1 = \frac{1}{T}\left[SR - SeC - HC - DC - SC - IP_1 + IE_1\right] \quad (23)$$

$$\pi_2 = \frac{1}{T}\left[SR - SeC - HC - DC - SC - IP_2 + IE_1\right] \quad (24)$$

$$\pi_3 = \frac{1}{T}\left[SR - SeC - HC - DC - SC - IP_3 + IE_1\right] \quad (25)$$

$$\pi_4 = \frac{1}{T}\left[SR - SeC - HC - DC - SC - IP_4 + IE_2\right] \quad (26)$$

The optimal value of T* and p* (say), which maximizes π_i can be obtained by solving equation (23), (24), (25) and (26) by differentiating it with respect to T and p and equate it to zero, we have

i.e. $$\frac{\partial \pi_i(T,p)}{\partial T} = 0, \quad \frac{\partial \pi_i(T,p)}{\partial p} = 0, \quad i=1,2,3,4 \quad (27)$$

provided it satisfies the condition

$$\begin{vmatrix} \frac{\partial \pi_i^2(T,p)}{\partial T^2} & \frac{\partial \pi_i^2(T,p)}{\partial T \partial p} \\ \frac{\partial \pi_i^2(T,p)}{\partial p \partial T} & \frac{\partial \pi_i^2(T,p)}{\partial p^2} \end{vmatrix} > 0 \quad i=1,2,3,4. \quad (28)$$

4. NUMERICAL EXAMPLE:

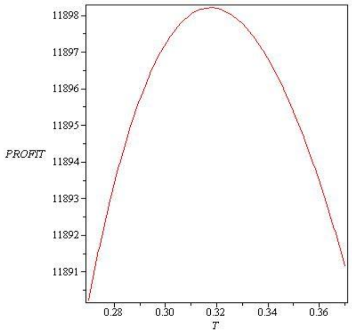
Case I: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, η=2, ρ= 5, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, R = 0.06, Ie = 0.12, Ip = 0.15, M = 0.06 in appropriate units. The optimal value of T*=0.3176, p* = 50.3586, Profit*= Rs. 11898.2205.

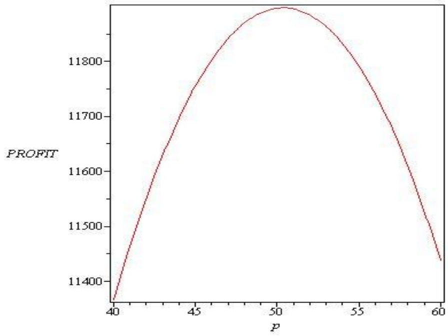
Case II: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, η=2, ρ= 5, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, R = 0.06, Ie = 0.12, Ip = 0.15, M = 0.12 in appropriate units. The optimal value of T*=0.2951, p* = 50.2962, Profit*= Rs. 11940.8255.

Case III: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, η=2, ρ= 5, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, R = 0.06, Ie = 0.12, Ip = 0.15, M = 0.20 in appropriate units. The optimal value of T*=0.2741, p* = 50.2067, Profit*= Rs. 12038.4549.

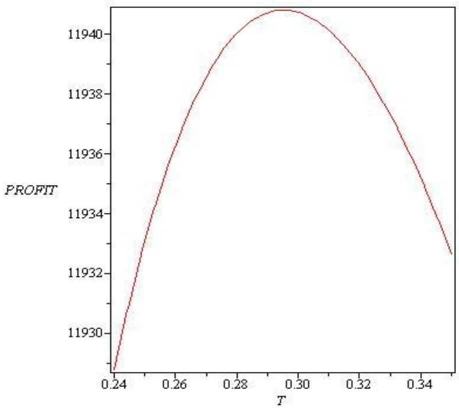
Case IV: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, η=2, ρ= 5, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, R = 0.06, Ie = 0.12, Ip = 0.15, M = 0.28 in appropriate units. The optimal value of T*=0.2596, p* = 50.1763, Profit*= Rs. 12152.4428.

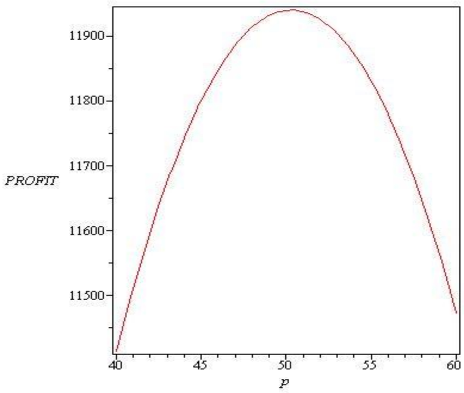
The second order conditions given in equation (28) are also satisfied. The graphical representation of the concavity of the profit function is also given.

<table>
<tr><td colspan="2">Case I</td></tr>
<tr><td>T and Profit</td><td>p and Profit</td></tr>
<tr><td>

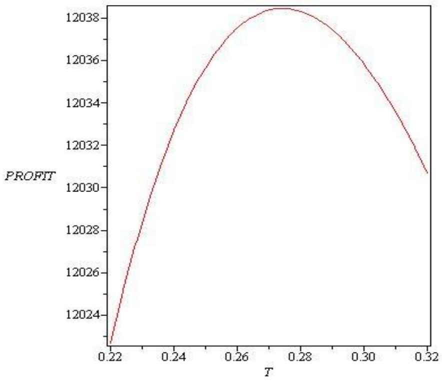
Graph 1</td><td>

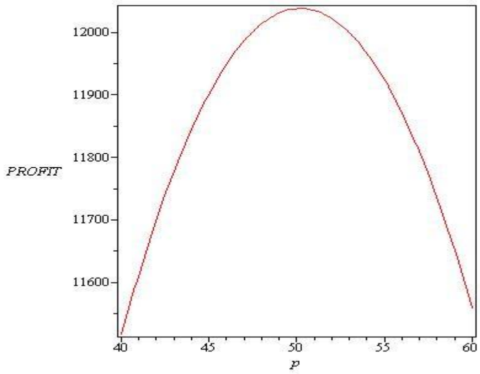
Graph 2</td></tr>
</table>

<table>
<tr><td colspan="2">Case II</td></tr>
<tr><td>T and Profit</td><td>p and Profit</td></tr>
<tr><td>

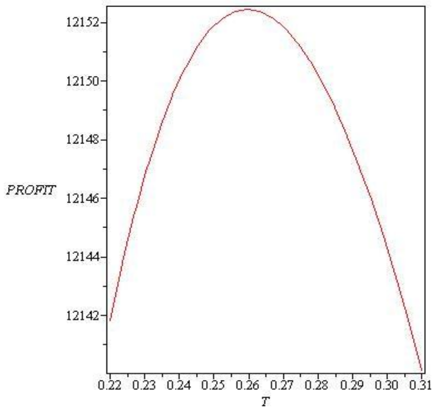
Graph 3</td><td>

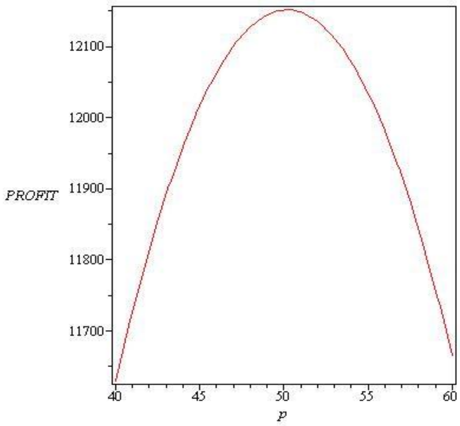
Graph 4</td></tr>
</table>

<table>
<tr><th colspan="2">Case III</th></tr>
<tr><td>T and Profit</td><td>p and Profit</td></tr>
<tr><td>

Graph 5</td><td>

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

<table>
<tr><th colspan="2">Case IV</th></tr>
<tr><td>T and Profit</td><td>p and Profit</td></tr>
<tr><td>

Graph 7</td><td>

Graph 8</td></tr>
</table>

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

Sensitivity Analysis

Parameter	%	T	p	Profit
a	+20%	0.2768	60.3090	17320.5881
	+10%	0.2958	55.3322	14483.9117
	-10%	0.3429	45.3893	9563.5869
	-20%	0.3728	40.4255	7480.1221
θ	+20%	0.3163	50.3612	11896.1560
	+10%	0.3170	50.3599	11897.1868
	-10%	0.3183	50.3573	11899.2572
	-20%	0.3190	50.3561	11900.2968
x	+20%	0.3080	50.3854	11879.0040
	+10%	0.3127	50.3723	11888.5375
	-10%	0.3228	50.3448	11908.0601
	-20%	0.3283	50.3305	11918.0640
A	+20%	0.3492	50.3970	11838.2405
	+10%	0.3338	50.3783	11867.5203
	-10%	0.3006	50.3379	11930.5706
	-20%	0.2825	50.3159	11964.8697
M	+20%	0.3144	50.3499	11904.2880
	+10%	0.3161	50.3544	11901.1092
	-10%	0.3190	50.3624	11895.6180
	-20%	0.3202	50.3657	11893.2982
R	+20%	0.3061	50.3446	11875.1665
	+10%	0.3118	50.3514	11886.5886
	-10%	0.3239	50.3663	11910.0741
	-20%	0.3305	50.3743	11922.1623
ρ	+20%	0.3295	42.0396	9833.7831
	+10%	0.3240	45.8208	10772.0581
	-10%	0.3103	55.9054	13274.9621
	-20%	0.3019	62.8397	14996.3485

Table 2

Case II

Sensitivity Analysis

Parameter	%	T	p	Profit
a	+20%	0.2496	60.2345	17387.4787
	+10%	0.2710	55.2639	14537.7145
	-10%	0.3227	45.3326	9596.6922
	-20%	0.3547	40.3742	7505.2535
θ	+20%	0.2939	50.2985	11938.9358
	+10%	0.2945	50.2973	11939.8793
	-10%	0.2957	50.2951	11941.7741
	-20%	0.2963	50.2940	11942.7254
x	+20%	0.2861	50.3199	11922.9362
	+10%	0.2905	50.3082	11931.8112
	-10%	0.2999	50.2840	11949.9857
	-20%	0.3050	50.2713	11959.2990
A	+20%	0.3289	50.3408	11876.7286
	+10%	0.3125	50.3192	11907.9104
	-10%	0.2767	50.2715	11975.8001
	-20%	0.2569	50.2446	12013.2779
M	+20%	0.2811	50.2561	11967.3365
	+10%	0.2885	50.2775	11953.3230
	-10%	0.3010	50.3127	11929.7456
	-20%	0.3061	50.3270	11920.0035
R	+20%	0.2844	50.2819	11919.3304
	+10%	0.2896	50.2889	11929.9805
	-10%	0.3009	50.3040	11951.8763
	-20%	0.3071	50.3122	11963.1453
ρ	+20%	0.3087	41.9809	9870.4518
	+10%	0.3024	45.7604	10811.3866
	-10%	0.2867	55.8407	13321.6976
	-20%	0.2769	62.7719	15048.4430

Table 3

Case III

Sensitivity Analysis

Parameter	%	T	p	Profit
a	+20%	0.2295	60.1602	17531.4123
	+10%	0.2509	55.1913	14657.0371
	-10%	0.2999	45.2373	9675.1327
	-20%	0.3091	40.2742	7566.6718
θ	+20%	0.2732	50.2092	12036.7226
	+10%	0.2737	50.2080	12037.5878
	-10%	0.2746	50.2055	12039.3239
	-20%	0.2750	50.2043	12040.1947
x	+20%	0.2673	50.2322	12021.7488
	+10%	0.2706	50.2196	12030.0488
	-10%	0.2777	50.1937	12046.9712
	-20%	0.2815	50.1803	12055.6021
A	+20%	0.3034	50.2416	11969.2040
	+10%	0.2892	50.2243	12002.9517
	-10%	0.2582	50.1891	12076.0198
	-20%	0.2413	50.1716	12116.0533
M	+20%	0.2664	50.1845	12093.5073
	+10%	0.2705	50.1940	12065.5199
	-10%	0.2774	50.2225	12012.2780
	-20%	0.2803	50.2412	11986.9606
R	+20%	0.2661	50.1977	12018.1941
	+10%	0.2700	50.2021	12078.2542
	-10%	0.2784	50.2117	12048.8113
	-20%	0.2830	50.2170	12059.3277
ρ	+20%	0.2895	41.8912	9955.1111
	+10%	0.2824	45.6708	10901.8450
	-10%	0.2644	55.7514	13428.4259
	-20%	0.2526	62.6832	15167.0997

Table 4

Case IV

Sensitivity Analysis

Parameter	%	T	p	Profit
a	+20%	0.2208	60.1492	17702.1297
	+10%	0.2386	55.1617	14798.0465
	-10%	0.2845	45.1940	9765.3426
	-20%	0.3149	40.2156	7636.7809
θ	+20%	0.2589	50.1791	12150.8203
	+10%	0.2592	50.1777	12151.6308
	-10%	0.2599	50.1750	12153.2561
	-20%	0.2602	50.1736	12154.0709
x	+20%	0.2544	50.2040	12136.5702
	+10%	0.2569	50.1903	12144.4660
	-10%	0.2622	50.1621	12160.5031
	-20%	0.2650	50.1477	12168.6494
A	+20%	0.2841	50.1937	12078.8677
	+10%	0.2711	50.1852	12114.8247
	-10%	0.2463	50.1670	12191.9784
	-20%	0.2323	50.1573	12233.7615
M	+20%	0.2595	50.1752	12236.4461
	+10%	0.2595	50.1758	12194.4445
	-10%	0.2595	50.1769	12110.4411
	-20%	0.2595	50.1775	12068.4395
R	+20%	0.2591	50.1718	12132.9611
	+10%	0.2563	50.1740	12142.6400
	-10%	0.2629	50.1787	12162.3743
	-20%	0.2665	50.1812	12172.4397
ρ	+20%	0.2778	41.8558	10049.7646
	+10%	0.2690	45.6375	11005.0946
	-10%	0.2492	55.7247	13556.0198
	-20%	0.2379	62.6613	15312.2141

From the table we observe that as parameters a and M increases/ decreases average total profit also increases/ decreases.

Also, we observe that with increase and decrease in the value of x, A, R and ρ, there is corresponding decrease/ increase in total profit.

From the table we observe that as parameter θ increases/ decreases, there is very slight change in average total profit.

6. CONCLUSION:

In this paper, we have developed a production inventory model for deteriorating items with linear demand with different deterioration rates under permissible delay in payments and inflation. 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.

REFERENCES

[1] Aggarwal, S.P. and Jaggi, C.K. (1995): Ordering policies for deteriorating items under permissible delay in payments; J. Oper. Res. Soc., Vol. 46, pp. 658-662.

[2] Buzacott, J.A. (1975): Economic order quantity with inflation; Operations Research Quarterly, Vol. 26, pp. 553-558.

[3] Chang, C.T., Teng, J.T. and Goyal, S.K. (2008): Inventory lot sizing models under trade credits; Asia Pacific J. Oper. Res., Vol. 25, pp. 89-112.

[4] Choi, S. and Hwang, H. (1986): Optimization of production planning problem with continuously distributed time-lags; International J. System Science; Vol. 17, pp. 1499-1508.

[5] Chung, H.J. and Dye, C.Y. (2002): An inventory model for deteriorating items under the condition of permissible delay in payments; Yugoslav Journal of Operational Research, Vol. 1, pp. 73-84.

[6] Chung, K.J., Goyal, S.K. and Huang, Y.F. (2005): The optimal inventory policies under permissible delay in payments depredating on the ordering quantity; International Journal of production economics, Vol. 95, pp. 203-213.

[7] Goyal, S.K. (1985): Economic order quantity under conditions of permissible delay in payments, J. O.R. Soc., Vol. 36, pp. 335-338.

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

[9] Manna, S.K. and Chiang, C. (2010): Economic production quantity models for deteriorating item with ramp type demand; International J. Oper. Res., Vol. 7, pp. 429-444.

[10] Mishra, R.B. (1975a): Optimum production lot size model for a system with deteriorating inventory; International J. Production Economics, Vol. 13, pp. 495-505.

[11] Mishra,R.B. (1975b): A study of inflationary effects on inventory systems; Logistic Spectrum, Vol. 9, pp. 260-268.

[12] Mishra,R.B. (1979): A note on optimal inventory management under inflation; Naval Research Logistic Quarterly, Vol. 26, pp. 161-165.

[13] Panda, S., Saha, S. and Basu, M. (2009): Optimal production stopping time for perishable products with ramp type quadratic demand dependent production and setup cost; CEJOR, Vol. 17, pp. 381-396.

[14] Patel, R. and Patel, S.S. (2013): Deteriorating items production inventory model with demand dependent production rate and varying holding cost; Indian J. Mathematics Research, Vol. 1, No.1, pp. 61-70.

[15] Patel, S.S. and Patel, R. (2013): An inventory model for weibull deteriorating items with linear demand, shortages under permissible delay in payments and inflation; International Journal of Mathematics and Statistics Invention, Vol. 1, No. 1, pp. 22-30.

[16] Patra, S.K., Lenka, T.K. and Ratha, P.C. (2010): An order level EOQ model for deteriorating items in a single warehouse system with price dependent demand in nonlinear (quadratic) form; Int. J. Computational and Appl. Math., Vol. 5, pp. 277-288.

[17] Roy, T. and Chaudhary, K.S. (2009): A production inventory model under stock dependent demand, Weibull distribution deterioration and shortages; International Transactions in Operations Research, Vol. 16, pp. 325-346.

[18] Sahoo, N.K., Sahoo, C.K. and Sahoo, S.K. (2010): An inventory model for constant deteriorating items with price dependent demand and time varying holding cost; International J. Comp. Sci.,Commun., Vol. 1(1), pp. 267-271.

[19] Salameh, M.K., Abbound, N.E., Ei-Kassar, A.N. and Ghattas, R.E. (2003): Continuous review inventory model with delay in payment; International Journal of production economics, Vol. 85, pp. 91-95.

[20] Singh, S. (2011) An economic order quantity model for items having linear demand under inflation and permissible delay in payments; International J. of Computer Applications, Vol. 33, pp. 48- 55.

[21] You, S.P. (2005): Inventory policy for products with price and time dependent demands; J. Oper. Res. Soc., Vol. 56, pp. 870-873.