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Production Inventory Model For Deteriorating Items With Different Deterioration Rates Under Stock And Price Dependent Demand And Shortages Under Inflation And Permissible Delay In Payments

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Abstract

A deteriorating items production inventory model with time and price dependent demand under inflation and permissible delay in payments is developed. Different deterioration rates are considered in a cycle. Shortages are allowed. Numerical example is provided to illustrate the model and sensitivity analysis is also carried out for parameters.

Keywords: Production, Inventory model, Varying Deterioration, Price dependent demand, Time dependent demand, Shortages, Inflation, Permissible delay in payments

1. INTRODUCTION

Most of the items lose their characteristics overtime and this characteristic is defined as deterioration. Ghare and Achrader [2] was the first to describe optimum ordering policies for deteriorating items. Covert and Philip [1] derived an EOQ model for items with weibull distribution deterioration. Shah [11] further extended the model by considering shortages. Mandal and Phaujdar [5] presented an inventory model for stock dependent consumption rate. Haiping and Wang [4] studied an economic policy model for deteriorating items with time proportional demand. Other research work related to deteriorating items can be found in, for instance (Raafat [9], Goyal and Giri [3], Ruxian et al. [10]).

Tripathy and Mishra [12] dealt with development of an inventory model when the deterioration rate follows Weibull two parameter distribution, demand rate is a function of selling price and holding cost is time dependent. The model was developed by taking care of with and without shortage both cases. Mathew [6] developed an inventory model for deteriorating items with mixture of Weibull rate of decay and demand as function of both selling price and time. A deteriorating items production inventory model with demand dependent production rate was developed by Patel and Patel [8]. Patel and Parekh [7] developed an inventory model with stock dependent demand under shortages and variable selling price.

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. Demand of the product is price and stock dependent for the cycle time under time varying holding cost. Shortages are 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 ($P(t) = \eta D(t), \eta>0$)

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

SeC : Set-up cost

B : Set-up cost per order

c : Purchasing cost per unit

p : Selling price per unit

c_2 : Shortage cost per unit item per unit time

SC : Shortage cost

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

HC : Holding cost

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_1 : Order quantity at t_1
Q_2 : Shortages of quantity
Q : Order quantity
θ : Deterioration rate during $\mu_1 \le t \le t_1$, $0< \theta<1$
θt : Deterioration rate during , $t_1 \le t \le t_0$, $0< \theta<1$
π : Total relevant profit per unit time.

ASSUMPTIONS:

The following assumptions are considered for the development of two warehouse 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 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.

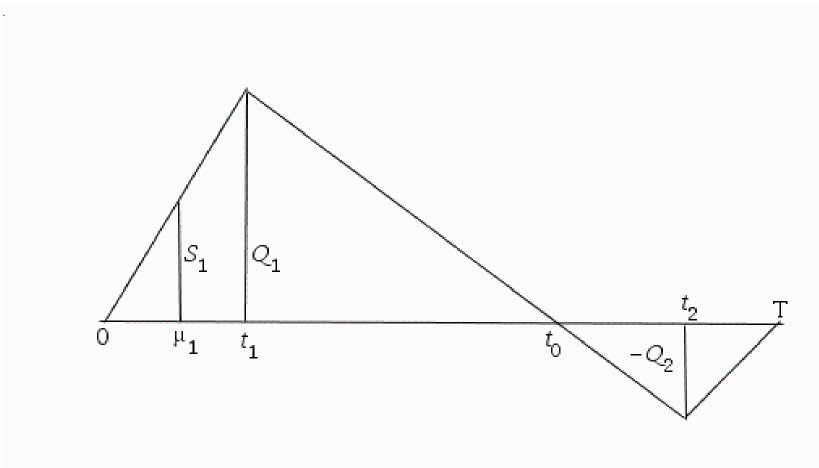


Figure 1

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

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

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

$$\frac{dI(t)}{dt} + \theta t I(t) = -(a + bt - \rho p), \qquad t_1 \le t \le t_0 \quad (3)$$

$$\frac{dI(t)}{dt} = -(a + bt - \rho p), \qquad t_0 \le t \le t_2 \quad (4)$$

$$\frac{dI(t)}{dt} = (\eta - 1)(a + bt - \rho p), \qquad t_2 \le t \le T \quad (5)$$

with initial conditions $I(0) = 0$, $I(\mu_1) = S_1$, $I(t_1) = Q_1$, $I(t_0) = 0$, $I(t_2) = -Q_2$ and $I(T) = 0$.

Solutions of these equations are given by

$$I(t) = (\eta - 1)\left((a - \rho p)t - \frac{1}{2}bt^2\right). \qquad (6)$$

$$I(t) = S_1\left[1 + \theta(\mu_1 - t)\right] - (\eta-1)\left[\begin{array}{l}(a - \rho p)(\mu_1 - t) + \frac{1}{2}b(\mu_1^2 - t^2) + \frac{1}{2}(a - \rho p)\theta(\mu_1^2 - t^2) \\ + \frac{1}{3}b\theta(\mu_1^3 - t^3) - (a - \rho p)\theta t(\mu_1 - t) - \frac{1}{2}b\theta t(\mu_1^2 - t^2)\end{array}\right] \qquad (7)$$

$$I(t) = \left[\begin{array}{l}(a - \rho p)(t_0 - t) + \frac{1}{2}b(t_0^2 - t^2) + \frac{1}{6}(a - \rho p)\theta(t_0^3 - t^3) \\ + \frac{1}{8}b\theta(t_0^4 - t^4) - \frac{1}{2}(a - \rho p)\theta t^2(t_0 - t) - \frac{1}{4}b\theta t^2(t_0^2 - t^2)\end{array}\right]. \qquad (8)$$

$$I(t) = (a - \rho p)\left[(t_0 - t) + \frac{1}{2}b(t_0^2 - t^2)\right]. \qquad (9)$$

$$I(t) = (\eta-1)\left[(a - \rho p)(t - T) - \frac{1}{2}b(t^2 - T^2)\right]. \qquad (10)$$

(by neglecting higher powers of θ)

Putting $t = \mu_1$ in equation (6), we get

$$S_1 = (\eta - 1)\left((a - \rho p)\mu_1 + \frac{1}{2}b\mu_1^2\right). \tag{11}$$

Putting $t = t_1$ in equations (7) and (8), we have

$$I(t) = S_1\left[1 + \theta\left(\mu_1 - t_1\right)\right] - (\eta\text{-}1)\left[\begin{array}{l}\left(a - \rho p\right)\left(\mu_1 - t_1\right) + \frac{1}{2}b\left(\mu_1^2 - t_1^2\right) + \frac{1}{2}\left(a - \rho p\right)\theta\left(\mu_1^2 - t_1^2\right) \\ + \frac{1}{3}b\theta\left(\mu_1^3 - t_1^3\right) - \left(a - \rho p\right)\theta t_1\left(\mu_1 - t_1\right) - \frac{1}{2}b\theta t_1\left(\mu_1^2 - t_1^2\right)\end{array}\right] \tag{12}$$

$$I(t_1) = \left[\begin{array}{l}\left(a - \rho p\right)\left(t_0 - t_1\right) + \frac{1}{2}b\left(t_0^2 - t_1^2\right) + \frac{1}{6}\left(a - \rho p\right)\theta\left(t_0^3 - t_1^3\right) \\ + \frac{1}{8}b\theta\left(t_0^4 - t_1^4\right) - \frac{1}{2}\left(a - \rho p\right)\theta t_1^2\left(t_0 - t_1\right) - \frac{1}{4}b\theta t_1^2\left(t_0^2 - t_1^2\right)\end{array}\right]. \tag{13}$$

So, from equations (12) and (13), we have

$$t_1 = \frac{\left[\left(a - \rho p\right)t_0 - S_1(1+\theta\mu_1) + (\eta\text{-}1)\left(a - \rho p\right)\mu_1\right]}{\left(a - \rho p\right) - S_1\theta + \left(a - \rho p\right)(\eta\text{-}1) + (\eta\text{-}1)\left(a - \rho p\right)\theta\mu_1} \tag{14}$$

From equation (14), we see that t_1 is a function of μ_1, t_0 and S_1, so t_1 is not a decision variable.

Similarly putting $t = t_2$ in equations (9) and (10), we have

$$I(t_2) = \left[\left(a - \rho p\right)\left(t_0 - t_2\right) + \frac{1}{2}b\left(t_0^2 - t_2^2\right)\right]. \tag{15}$$

$$I(t_2) = \left(\eta\text{-}1\right)\left[\left(a - \rho p\right)\left(t_2 - T\right) + \frac{1}{2}b\left(t_2^2 - T^2\right)\right]. \tag{16}$$

So from equations (15) and (16), we have

$$t_2 = \frac{t_0 + T\eta - T}{bt_0 + \eta} \tag{17}$$

From equation (17), we see that t_2 is a function of t_0, T and η, so t_2 is not a decision variable.

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

(i) Set-up cost (SeC) = B (18)

(ii) $HC = \int_0^{t_0} (x+yt)I(t)e^{-Rt}dt$

$$= \int_0^{\mu_1} (x+yt)I(t)e^{-Rt}dt + \int_{\mu_1}^{t_1} (x+yt)I(t)e^{-Rt}dt + \int_{t_1}^{t_0} (x+yt)I(t)e^{-Rt}dt \quad (19)$$

(iii) $$DC = c\left(\int_{\mu_1}^{t_1} \theta I(t)e^{-Rt}dt + \int_{t_1}^{t_0} \theta t I(t)e^{-Rt}dt\right) \quad (20)$$

(iv) $$SC = -c_2\left(\int_{t_0}^{T} I(t)e^{-Rt}dt\right) = -c_2\left(\int_{t_0}^{t_2} I(t)e^{-Rt}dt + \int_{t_2}^{T} I(t)e^{-Rt}dt\right) \quad (21)$$

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

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

Case I: $(0 \le M \le t_0)$ and Case II: $(0 \le t_0 \le M)$.

Case I: $(0 \le M \le t_0)$: 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_0.

(v) Interest earned per cycle:

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

Case II: $(0 \le t_0 \le M)$:

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:

$$IE_2 = pI_e\left[\int_0^{t_0} (a + bt - \rho p)\, te^{-Rt}dt + (a + bt_0 - \rho p)\, t_0 (M - t_0)\right] \quad (24)$$

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) $IP_1 = cI_p\int_{M}^{t_0} I(t)e^{-Rt}dt = cI_p\left(\int_{M}^{\mu_1} I(t)e^{-Rt}dt + \int_{\mu_1}^{t_1} I(t)e^{-Rt}dt + \int_{t_1}^{t_0} I(t)e^{-Rt}dt\right)$ (25)

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

(ix) $IP_2 = cI_p\int_{M}^{t_0} I(t)e^{-Rt}dt = cI_p\left(\int_{M}^{\mu_2} I(t)e^{-Rt}dt + \int_{\mu_2}^{t_0} I(t)e^{-Rt}dt\right)$ (26)

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

(x) $IP_3 = cI_p\int_{M}^{t_0} I(t)e^{-Rt}dt$ (27)

Case IV: ($M > t_0$):

(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:

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

Substituting values from equations (18) to (28) in equation (29), we get total profit per unit. Putting $\mu_1 = v_1 t_0$ in equation (29), we get profit in terms of t_0, T and p for the four cases as under:

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

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

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

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

The optimal value of t_0*, T* and p* (say), which maximizes π_i can be obtained by solving equation (31), (32), (33) and (34) with respect to t_0, T and p and equate it to zero, we have

$$\text{i.e. } \frac{\partial \pi_i(t_0,T,p)}{\partial t_0} = 0,\ \frac{\partial \pi_i(t_0,T,p)}{\partial T} = 0,\ \frac{\partial \pi_i(t_0,T,p)}{\partial p} = 0 \tag{34}$$

provided it satisfies the condition

$$\begin{vmatrix} \frac{\partial \pi_i^2(t_0,T,p)}{\partial t_0^2} & \frac{\partial \pi_i^2(t_0,T,p)}{\partial t_0 \partial T} & \frac{\partial \pi_i^2(t_0,T,p)}{\partial t_0 \partial p} \\ \frac{\partial \pi_i^2(t_0,T,p)}{\partial T \partial t_0} & \frac{\partial \pi_i^2(t_0,T,p)}{\partial T^2} & \frac{\partial \pi_i^2(t_0,T,p)}{\partial T \partial p} \\ \frac{\partial \pi_i^2(t_0,T,p)}{\partial p \partial t_0} & \frac{\partial \pi_i^2(t_0,T,p)}{\partial p \partial T} & \frac{\partial \pi_i^2(t_0,T,p)}{\partial p^2} \end{vmatrix} > 0 \tag{35}$$

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* = 0.2498, T*=0.3271, p* = 50.3313, Profit*= Rs. 11917.0647.

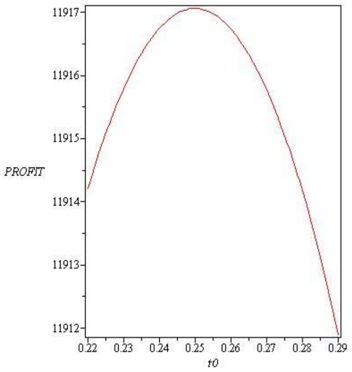
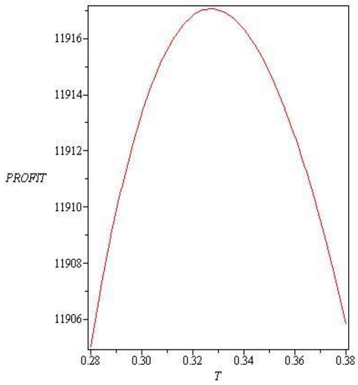
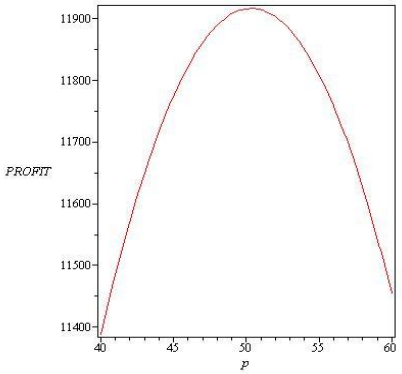
Case II: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, η=2, ρ= 5, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, R = 0.06, Ie = 0.12, Ip = 0.15, M = 0.10 in appropriate units. The optimal value of t_0* = 0.2394, T*=0.3136, p* = 50.2969, Profit*= Rs. 11941.2296.

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* = 0.2510, T*=0.2860, p* = 50.2095, Profit*= Rs. 12043.3833.

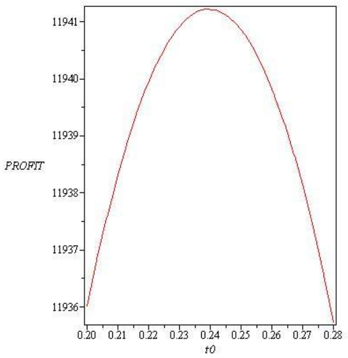
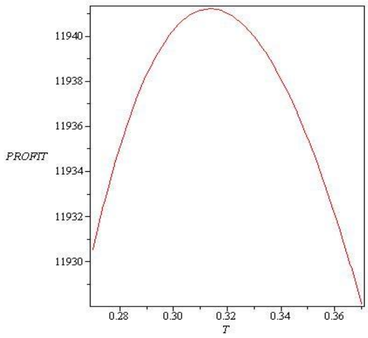
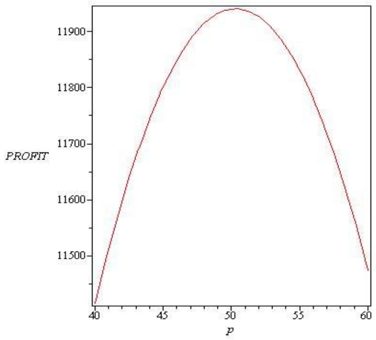
Case IV: Considering A= Rs.100, a = 500, b=0.05, c=Rs. 25, η=2, ρ= 5, θ=0.05, x = Rs. 5, y=0.05, v_1=0.30, R = 0.06, Ie = 0.12, Ip = 0.15, M = 0.25 in appropriate units. The optimal value of t_0* = 0.2532, T*=0.2660, p* = 50.1815, Profit*= Rs. 12108.1759.

The second order conditions given in equation (25) are also satisfied. The graphical representation of the concavity of the profit function is also given.

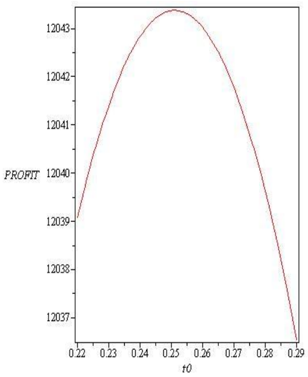
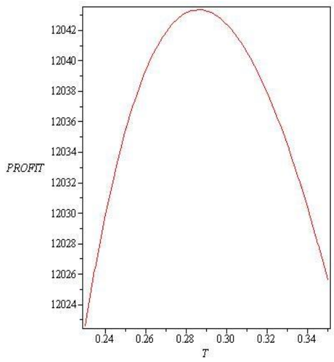
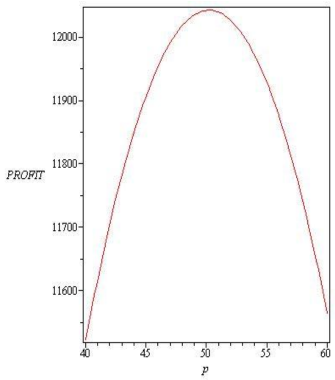
Case - I

t_0 and Profit	T and Profit	p and Profit
 Graph 1	 Graph 2	 Graph 3

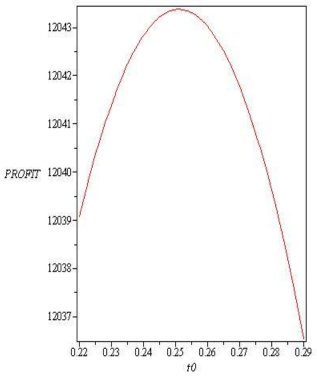
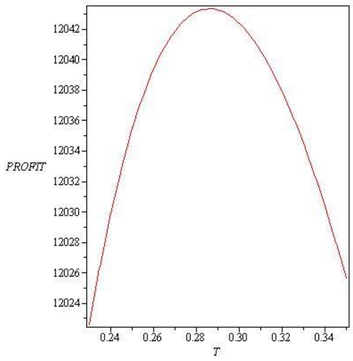
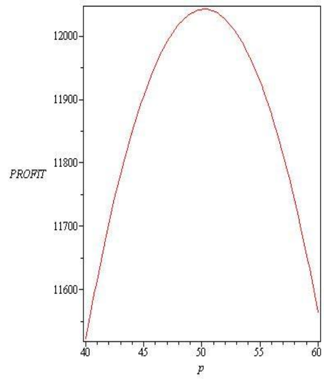
Case - II

t_0 and Profit	T and Profit	p and Profit
 Graph 4	 Graph 5	 Graph 6

Case - III

t_0 and Profit	T and Profit	p and Profit
 Graph 7	 Graph 8	 Graph 9

Case - IV

t_0 and Profit	T and Profit	p and Profit
 Graph 10	 Graph 11	 Graph 12

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_0	T	p	Profit
a	+20%	0.2172	0.2846	60.2845	17340.4880
	+10%	0.2324	0.3044	55.3063	14503.3202
	-10%	0.2701	0.3534	45.3603	9581.7817
	-20%	0.2941	0.3845	40.3945	7497.5671
θ	+20%	0.2480	0.3257	50.3332	11915.3880
	+10%	0.2489	0.3264	50.3322	11916.2246
	-10%	0.2507	0.3278	50.3303	11917.9083
	-20%	0.2516	0.3284	50.3293	11918.7555
x	+20%	0.2455	0.3161	50.3608	11896.2506
	+10%	0.2476	0.3214	50.3462	11906.5532
	-10%	0.2520	0.3330	50.3158	11927.7988
	-20%	0.2542	0.3394	50.2999	11938.7711
A	+20%	0.2748	0.3594	50.3669	11858.8045
	+10%	0.0.2626	0.3437	50.3495	11887.2483
	-10%	0.0.2364	0.3096	50.3120	11948.4755
	-20%	0.2250	0.2949	50.2958	11974.9433

M	+20%	0.2473	0.3238	50.3230	11922.9579
	+10%	0.2486	0.3255	50.3273	11919.8704
	-10%	0.2509	0.3285	50.3348	11914.5369
	-20%	0.2519	0.3297	50.3380	11912.2835
R	+20%	0.2402	0.3145	50.3175	11893.3143
	+10%	0.2448	0.3206	50.3242	11905.0751
	-10%	0.2551	0.3339	50.3388	11929.2966
	-20%	0.2607	0.3412	50.3468	11941.7858
ρ	+20%	0.2597	0.3400	42.0120	9853.2685
	+10%	0.2511	0.3339	45.7933	10791.2452
	-10%	0.2438	0.3192	55.8782	13293.4079
	-20%	0.2368	0.3101	62.8128	15014.3261
c_2	+20%	0.2557	0.3262	50.3337	11915.4372
	+10%	0.2529	0.3266	50.3325	11916.2142
	-10%	0.2464	0.3276	50.3299	11917.9997
	-20%	0.2426	0.3281	50.3284	11919.0326

Table 2
Case II
Sensitivity Analysis

Parameter	%	t_0	T	p	Profit
a	+20%	0.2048	0.2684	60.2438	17378.2457
	+10%	0.2210	0.2896	55.2688	14533.7693
	-10%	0.2607	0.3412	45.3289	9600.5938
	-20%	0.2857	0.3736	40.3660	7511.8710
θ	+20%	0.2378	0.3124	50.2984	11939.6493
	+10%	0.2386	0.3130	50.2978	11940.4378
	-10%	0.2403	0.3142	50.2960	11942.0247
	-20%	0.2412	0.3149	50.2951	11942.8231
x	+20%	0.2353	0.3031	50.3244	11921.2502
	+10%	0.2374	0.3082	50.3109	11931.1395
	-10%	0.2416	0.3193	50.2825	11951.5338
	-20%	0.2437	0.3254	50.2675	11962.0668
A	+20%	0.2654	0.3473	50.3358	11880.7075
	+10%	0.2527	0.3309	50.3169	11910.1988

	-10%	0.255	0.2953	50.2755	11974.0717
	-20%	0.2104	0.2758	50.2526	12009.0872
M	+20%	0.2321	0.3040	50.2719	11958.4300
	+10%	0.2360	0.3091	50.2851	11949.3751
	-10%	0.2426	0.3177	50.3073	11933.9554
	-20%	0.2453	0.3212	50.3165	11927.5202
R	+20%	0.2302	0.3016	50.2829	11918.4197
	+10%	0.2347	0.3074	50.2897	11929.7149
	-10%	0.2445	0.3202	50.3045	11952.9769
	-20%	0.2499	0.3272	50.3126	11964.9712
ρ	+20%	0.2502	0.3275	41.9795	9874.0648
	+10%	0.2452	0.3210	45.7599	10813.5515
	-10%	0.2329	0.3051	55.8426	13319.9135
	-20%	0.2253	0.2952	62.7756	15043.8638
c_2	+20%	0.2452	0.3128	50.2991	11939.6643
	+10%	0.2424	0.3132	50.2980	11940.4116
	-10%	0.2362	0.3141	50.2956	11942.1290
	-20%	0.2326	0.3146	50.2942	11943.1224

Table 3
Case III
Sensitivity Analysis

Parameter	%	t_0	T	p	Profit
a	+20%	0.2189	0.2351	60.1626	17532.9388
	+10%	0.2343	0.2595	55.1842	14660.1264
	-10%	0.2695	0.3154	45.2394	9682.0443
	-20%	0.2905	0.3486	40.2750	7575.6026
θ	+20%	0.2498	0.2853	50.2119	12041.8023
	+10%	0.2504	0.2857	50.2107	12042.5916
	-10%	0.2516	0.2865	50.2083	12044.1773
	-20%	0.2522	0.2869	50.2071	12044.9738
x	+20%	0.2469	0.2773	50.2357	12025.7736
	+10%	0.2489	0.2815	50.2228	12034.5024
	-10%	0.2531	0.2908	50.1959	12052.4261
	-20%	0.2552	0.2959	50.1820	12061.6420

A	+20%	0.2717	0.3188	50.2429	11977.2583
	+10%	0.2616	0.3029	50.2264	12009.4273
	-10%	0.2397	0.2682	50.1922	12079.4642
	-20%	0.2276	0.2490	50.1746	12118.1300
M	+20%	0.2566	0.2723	50.1874	12094.5091
	+10%	0.2541	0.2796	50.1975	12068.1524
	-10%	0.2474	0.2918	50.2234	12020.0987
	-20%	0.2434	0.2969	50.2387	11998.2157
R	+20%	0.2448	0.2763	50.1999	12022.3067
	+10%	0.2478	0.2810	50.2046	12032.7558
	-10%	0.2543	0.2914	50.2148	12054.1987
	-20%	0.2579	0.2970	50.2204	12065.2125
ρ	+20%	0.2624	0.3041	41.8942	9961.6574
	+10%	0.2571	0.2958	45.6737	10907.6262
	-10%	0.2438	0.2747	55.7540	13432.4053
	-20%	0.2352	0.2610	62.6857	15170.0332
c_2	+20%	0.2529	0.2851	50.2094	12042.9951
	+10%	0.2520	0.2856	50.2094	12043.1812
	-10%	0.2499	0.2866	50.2096	12043.6034
	-20%	0.2488	0.2872	50.2097	12043.8442

Table 4
Case IV
Sensitivity Analysis

Parameter	%	t_0	T	p	Profit
a	+20%	0.2276	0.2118	60.1466	17639.0060
	+10%	0.2393	0.2378	55.1618	14743.6076
	-10%	0.2703	0.2973	45.2058	9731.5580
	-20%	0.2917	0.3331	40.2348	7612.9161
θ	+20%	0.2524	0.2654	50.1843	12106.5999
	+10%	0.2528	0.2657	50.1829	12107.3870
	-10%	0.2537	0.2662	50.1801	12108.9665
	-20%	0.2541	0.2664	50.1787	12109.7588
x	+20%	0.2499	0.2587	50.2081	12091.9498
	+10%	0.2516	0.2622	50.1950	12100.0037
	-10%	0.2550	0.2699	50.1678	12116.4739
	-20%	0.2567	0.2741	50.1538	12124.9062

A	+20%	0.2695	0.2979	50.2065	12037.3436
	+10%	0.2616	0.2824	50.1941	12071.7058
	-10%	0.2444	0.2484	50.1689	12147.0554
	-20%	0.2348	0.2295	50.1564	12188.9008
M	+20%	0.2680	0.2489	50.1723	12184.1283
	+10%	0.2609	0.2579	50.1756	12144.9855
	-10%	0.2451	0.2730	50.1896	12073.5000
	-20%	0.2365	0.2792	50.1994	12040.7950
R	+20%	2486	0.2574	50.1753	12088.3306
	+10%	0.2509	0.2616	50.1783	12098.1734
	-10%	0.2558	0.2705	50.1850	12118.3461
	-20%	0.2584	0.2754	50.1886	12128.6925
ρ	+20%	0.2661	0.2881	41.8649	10014.2513
	+10%	0.2598	0.2777	45.6449	10965.5655
	-10%	0.2464	0.2523	55.7273	13506.1929
	-20%	0.2420	0.2431	61.6892	15205.7721
c_2	+20%	0.2537	0.2654	50.1812	12108.1209
	+10%	0.2535	0.2657	50.1813	12108.1473
	-10%	0.2530	0.2662	50.1817	12108.2068
	-20%	0.2527	0.2665	50.1819	12108.2405

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 θ and x, there is corresponding decrease/ increase in total profit and optimum order quantity.

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

6. CONCLUSION:

In this paper, we have developed a production inventory model for deteriorating items with price and inventory level 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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