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An Order Level Inventory Model for a Deteriorating Item with Constant Deterioration, Exponential Demand and Shortages

Devendra Singh[1] Pushpa Rao[2] Dinesh Singh[3]

[1]Haryana Institute of Public Administration, Gurgaon, India

[2]Inderprastha Engineering College, Ghaziabad, India

[3]S.G.R.R.(P.G.) College, Dehradun, India, Corresponding Author E-mail id: doon.dinesh@gmail.com

Abstract – An Inventory model is developed for a deteriorating item with constant deteriorating rate having an instantaneous supply, an exponential demand and shortages in Inventory. The model is solved analytically to obtain the optimal solution of the problem. It is then illustrated with the help of numerical example. The sensitivity of the optimal solution towards changes in the values of different parameters is also studied.

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1. INTRODUCTION AND REVIEW OF LITERATURES

The aim of the paper is to develop an Economic order quantity Model (EOQ model) for a single item inventory having an exponential demand.

A brief review of the literature dealing with time varying demands is made in the following paragraphs.

In formulating inventory model, two factors of the problem have been growing interest to the researchers, one being the deterioration of the items and other being the variation in the demand rate with time. Silver and Meal(1969) developed an approximate solution procedure for the general case of the deterministic, time varying demand pattern. The classical no shortage inventory problem for a linear trend in demand over a finite time horizon was analytically solved by Donaldson (1977). However, Donaldson's solution procedure was computationally complicated. Silver (1979) derived a heuristic for a special case of a positive, linear trend in demand and applied it to the problem of Donaldson (1977). Ritchie (1980, 1984 and 1985) obtained an exact solution, having the simplicity of the EOQ formula, for Donaldson's problem for a linear increasing demand.

Mitra et al (1984) presented a simple procedure for adjusting the economic order quantity model for the case of increasing or decreasing linear trend in demand. The possibilities of shortage and deterioration in inventory were left out of consideration in all these models.

Dave and Paul (1981) developed an inventory model for deteriorating items with time proportional demand.

This model was extended by Sachan(1984) to cover the backlogging option. Bahari- Kaushari (1989) discussed a heuristic model for obtaining order quantities when demand is time proportional and inventory deteriorates at a constant rate over time. Deb and Chaudhuri (1987) studied the inventory replenishment policy for items having a deterministic demand pattern with linear (positive) trend and shortages; they developed a heuristic to determine the decision role for soliciting the items and sizes of replenishment over a finite time- horizon so as to keep the total costs minimum. This work was extended my Murdeshwar(1988), Subsequent contribution in this direction came from researchers. Like Goyal (1986, 1988), Dave (1989), Hariga (1994), Goswami and Chaudhari(1991), XU and Wang (1991), Chung and Ting(1993), Kim(1995), Hariga(1995, 1996), Jalan, Giri and Chaudhuri(1996), Jalan and Chaudhuri(1999), Lin, Ton and Lee (2000) etc.

These investigations were followed by several researchers like Shah and Jaiswal (1977), Aggarwal (1979), Roy – Chowhuri and Chaudhuri (1983). The Model Developed by Covert and Philip (1973), Philip (1974) and Mishra (1975) did not allowed shortages in inventory and used a constant demand rate.

Wee (1995) and Jalan and Chaudhuri (1999) worked with an exponentially time varying demand.

Recently Ghosh and Chaudhuri (2004) have obtained an inventory model for a deteriorating item with **Weibull Distribution** deterioration, time quadratic demand and shortages.

In the paper, we assume that time dependence of the demand rate is exponential. Deterioration rate is assumed to be a constant and shortages in the inventory are allowed. An analytical solution of the model is discussed and it is illustrated with the help of numerical example. Sensitivity of the optimal solution with respect to changes in different parameter values is also examined.

2. NOTATIONS

The following notations are used in the model.

C_1- inventory carrying cost per unit per unit time.

C_2- Shortage cost per unit time

C_3- ordering cost per order

C_4- cost of a unit.

I_0 – Size of initial inventory

K – a constant value (0<K<1)

t_1 .time during which there is no shortage($0<t_1<T$)

T*- Optimal value of T

I_0^* - Optimal value of I_0

t_1^* – optimal value of t_1

K* - Optimal value of K

3. ASSUMPTIONS:

The following assumptions are used for this model;

(i) The Demand rate R(t) varies exponentially with time . i.e $R(t)=\lambda_0 e^{\alpha t}$, λ_0, α are constants

(ii) Shortage in the inventory are allowed and completely backlogged.

(iii) The supply is instantaneous and the lead time is zero.

(iv) A deteriorateditem is not repaired or replaced during a given cycle.

(v) The holding cost, ordering cost, shortage cost and unit cost remain constant over time.

4. FORMULATION AND SOLUTION

The instantaneous State of the inventory level I(t) at any time t is governed by differential equations

$$\frac{dI(t)}{dt} + \theta . I(t) = -\lambda_0 e^{\alpha t} \qquad 0 \le t \le t_1 \qquad (4.1)$$

With $I(0) = I_0$ and $I(t_1) = 0$

and

$$\frac{dI(t)}{dt} = -\lambda_0 e^{\alpha t}, t_1 \le t \le T \qquad (4.2)$$

with $I(t_1)= 0$

The Solutions of Eq. (4.1)and Eq.(4.2)are respectively given by

$$I(t) = \frac{\lambda_0}{(\alpha+\theta)}\left(e^{(\alpha+\theta)t_1-\theta t} - e^{\alpha t}\right) 0 \le t \le t_1 \qquad (4.3)$$

and

$$I(t) = \frac{\lambda_0}{\alpha}\left(e^{\alpha t_1} - e^{\alpha t}\right) t_1 \le\le T \qquad (4.4)$$

also

$$I_0 = \frac{\lambda_0}{(\alpha+\theta)}\left(e^{(\alpha+\theta)t_1} - 1\right) = \frac{\lambda_0}{(\alpha+\theta)}\left(e^{(\alpha+\theta)KT} - 1\right)$$

Since the length of the shortage interval is a part of the cycle time, we may assume

$$t_1 = KT, \quad 0<K<1 \qquad (4.5)$$

Where K is a constant to be determined in an optimal manner. Now we can write

$$I_0 = \frac{\lambda_0}{(\alpha+\theta)}\left(e^{(\alpha+\theta)KT} - 1\right) \qquad (4.6)$$

The Inventory level at the beginning of the cycle must be sufficient enough to meet the total demand given by

$$\int_0^{t_1} \lambda_0 e^{\alpha t} dt = \frac{\lambda_0}{\alpha}\left(e^{\alpha t_1} - 1\right) \qquad (4.7)$$

The total quantity of deteriorated item is given by

$$I_0 - \frac{\lambda_0}{\alpha}\left(e^{\alpha t_1} - 1\right) \qquad (4.8)$$

Average Inventory Holding Cost

The average inventory holding cost in (0, t_1) is

$$\frac{C_1}{T}\int_o^{t_1} I(t)dt = \frac{C_1}{T}\frac{\lambda_0}{(\alpha+\theta)}\int_o^{t_1} \left(e^{(\alpha+\theta)t_1-\theta t} - e^{\alpha t}\right)dt$$

$$= \frac{C_1\lambda_0}{\alpha\theta(\alpha+\theta)T}\left(\left(\theta + \alpha e^{(\alpha+\theta)t_1}\right) - (\alpha+\theta)e^{\alpha t_1}\right) \qquad (4.9)$$

Average Shortage Cost

The average shortage cost in [t_1, T] is given by

$$\frac{C_2}{T}\int_{t_1}^{T}\lambda_0 e^{\alpha t}(T-t)dt = \frac{\lambda_0 C_2}{\alpha T}\left[\frac{1}{\alpha}\left(e^{\alpha T} - e^{\alpha t_1}\right) - (T-t_1)e^{\alpha t_1}\right] \qquad (4.10)$$

Average Ordering Cost

The average ordering cost is given by

$$\frac{C_3}{T} \qquad (4.11)$$

The Average Cost of Deterioration

Cost of deteriorating item per unit time is given by

$$\frac{C_4}{T}\left\{I_0 - \frac{\lambda_0}{\alpha}\left(e^{\alpha t_1} - 1\right)\right\} = \frac{\lambda_0 C_4}{T}\left\{\frac{e^{(\alpha+\theta)t_1}}{(\alpha+\theta)} - \frac{1}{\alpha}e^{\alpha t_1} + \frac{\theta}{\alpha(\alpha+\theta)}\right\} \qquad (4.12)$$

Average variable cost (AVC) per unit time is

$$AVC = \frac{\lambda_0 C_1}{\alpha\theta(\alpha+\theta)T}\left(\theta + \alpha e^{(\alpha+\theta)t_1} - (\alpha+\theta)e^{\alpha t_1}\right)$$

$$+\frac{\lambda_0 C_2}{\alpha T}\left(\frac{1}{\alpha}\left(e^{\alpha T} - e^{\alpha t_1}\right) - (T-t_1)e^{\alpha t_1}\right) + \frac{C_3}{T}$$

$$+\frac{\lambda_0 C_4}{T}\left(\frac{e^{(\alpha+\theta)t_1}}{(\alpha+\theta)} - \frac{1}{\alpha}e^{\alpha t_1} + \frac{\theta}{\alpha(\alpha+\theta)}\right) \qquad (4.13)$$

Now

$$\mathbf{AVC} = \frac{\lambda_0 C_1}{\alpha\theta(\alpha+\theta)T}\left(\alpha e^{(\alpha+\theta)KT} - (\alpha+\theta)e^{\alpha KT} + \theta\right)$$

$$+\frac{\lambda_0 C_2}{\alpha T}\left(\frac{1}{\alpha}e^{\alpha T} - (T - KT + \frac{1}{\alpha})e^{\alpha KT}\right) + \frac{C_3}{T}$$

$$+\frac{\lambda_0 C_4}{T}\left(\frac{e^{(\alpha+\theta)KT}}{(\alpha+\theta)} - \frac{1}{\alpha}e^{\alpha KT} + \frac{\theta}{\alpha(\alpha+\theta)}\right)$$

$$=\frac{\lambda_0}{T}\left[\frac{C_1+C_4\theta}{\theta(\alpha+\theta)}e^{(\alpha+\theta)KT} - \left\{\frac{C_2T(1-K)}{\alpha} + \frac{1}{\alpha}\left(\frac{C_1}{\theta} + \frac{C_2}{\alpha} + C_4\right)\right\}e^{\alpha KT}\right\} + \frac{C_2}{\alpha^2}e^{\alpha T} +$$

$$\left(\frac{C_1+C_4\theta}{\alpha(\alpha+\theta)} + \frac{C_3}{\lambda_0}\right)\right] \qquad (4.14)$$

Treating K and T as decision variables, the necessary conditions for the minimization of the average system cost are

$$\frac{\partial}{\partial T}(AVC) = 0 \qquad (4.15)$$

and

$$\frac{\partial}{\partial K}(AVC) = 0 \qquad (4.16)$$

After a little calculation, $\frac{\partial}{\partial T}(AVC)$ becomes

$$= \frac{\lambda_0}{T}\left(\frac{(C_1+C_4\theta)(\alpha+\theta)K}{\theta(\alpha+\theta)}e^{(\alpha+\theta)KT} + \frac{C_2}{\alpha}e^{\alpha T} - \left(\frac{C_1}{\theta} + \frac{C_2}{\alpha} + C_4\right)Ke^{\alpha KT}\right)$$

$$= \frac{\lambda_0}{T^2}\left\{\frac{(C_1+C_4\theta)}{\theta(\alpha+\theta)}e^{(\alpha+\theta)KT} + \frac{C_2}{\alpha^2}e^{\alpha T} - \frac{1}{\alpha}\left(\frac{C_1}{\theta} + \frac{C_2}{\alpha} + C_4\right)e^{\alpha KT} + \left(\frac{(C_1+C_4\theta)}{\alpha(\alpha+\theta)} + \frac{C_3}{\lambda_0}\right)\right\}$$

$$-\frac{\lambda_0 C_2}{\alpha}(1-K)\alpha Ke^{\alpha KT}$$

i.e

$$\frac{\partial}{\partial T}(AVC) = \frac{\lambda_0}{T^2}\left[\frac{(C_1+C_4\theta)}{\theta}\left\{KT - \frac{1}{(\alpha+\theta)}\right\}e^{(\alpha+\theta)KT}\right.$$

$$+ \left\{\frac{(\alpha C_1 + \theta C_2 + \alpha\theta C_4)(1-\alpha KT) - C_2\alpha^2\theta(1-K)KT^2}{\alpha^2\theta}\right\}e^{\alpha KT}$$

$$+\frac{C_2(\alpha T - 1)}{\alpha^2}e^{\alpha T}$$

$$-\left(\frac{(C_1+C_4\theta)}{\alpha(\alpha+\theta)}\right.$$

$$\left.\left.+\frac{C_3}{\lambda_0}\right)\right] \qquad (4.17)$$

Now (15) yields

$$\frac{(C_1+C_4\theta)}{\theta(\alpha+\theta)}\{(\alpha+\theta)KT - 1\}e^{(\alpha+\theta)KT} - \left\{\frac{(\alpha C_1+\theta C_2+\alpha\theta C_4)(1-\alpha KT)}{\alpha^2\theta} - C_2(1-K)KT^2\right\}e^{\alpha KT} +$$

$$\frac{C_2(\alpha T-1)}{\alpha^2}e^{\alpha T} - \left(\frac{(C_1+C_4\theta)}{\alpha(\alpha+\theta)} + \frac{C_3}{\lambda_0}\right) = 0 \qquad (4.18)$$

After a little calculation, $\frac{\partial}{\partial K}(AVC)$ becomes

$$\frac{\partial}{\partial K}(AVC) = \frac{\lambda_0}{T}\left[\frac{(C_1 + C_4\theta)}{\theta} Te^{(\alpha+\theta)KT}\right.$$

$$\left. - \frac{T}{\alpha} e^{\alpha KT}\left\{\alpha\left(\frac{C_1}{\theta} + \frac{C_2}{\alpha} + C_4\right) + \; C_2 T(1-K)\alpha - C_2\right\}\right]$$

i.e

9K (∀∧C) = θL/y⁰ [(Cᴵ + C⁺θ)Lɛ θKL − {(Cᴵ + C⁺θ) + CˢθL(I − K)}L]ɛ αKL
9

$$\frac{\partial}{\partial K}(AVC) = \frac{\lambda_0}{\theta}(C_1 + C_4\theta))e^{\theta KT} - \{(C_1 + C_4\theta) + C_2\theta(1-K)T\}e^{\alpha KT} \quad (4.19)$$

Now (16) yields

$$\alpha(C_1 + C_4\theta)e^{\theta KT} - C_2\alpha\theta(1-K)T - \alpha(\theta C_4 + C_1) = 0 \qquad (4.20)$$

We can easily calculate

$$\frac{\partial^2}{\partial T^2}(AVC) = \frac{\lambda_0}{T^3}\left[\frac{(C_1 + C_4\theta)}{\theta(\alpha+\theta)}\{(\alpha+\theta)^2K^2T^2 - 2(\alpha+\theta)KT + 2\}e^{(\alpha+\theta)KT}\right.$$

$$-\frac{1}{\alpha}\left\{\left(\frac{C_1}{\theta} + \frac{C_2}{\alpha} + C_4\right)(\alpha^2K^2T - 2\,\alpha\,KT + 2) + C_2\alpha^2(1-K)K^2T^3\right\}e^{\alpha KT}$$

$$\left. + \frac{C_2}{\alpha^2}(\alpha^2T^2 - 2\,\alpha\,T + 2) + 2\left(\frac{(C_1 + C_4\theta)}{\alpha(\alpha+\theta)} + \frac{C_3}{\lambda_0}\right)\right] \quad (4.21)$$

$$\frac{\partial^2}{\partial K^2}(AVC) = \frac{\lambda_0}{\theta}\left[\alpha T\left\{(C_1 + C_4\theta)e^{\theta KT} - \{(C_1 + C_4\theta) + C_2\theta(1-K)T\}\right\}e^{\alpha KT}\right.$$

$$\left. + \left\{(C_1 + C_4\theta)\theta Te^{\theta KT} - \{-C_2\theta T\}\right\}e^{\alpha KT}\right]$$

$$= \frac{\lambda_0}{\theta}T[(\alpha+\theta)(C_1 + C_4\theta)e^{\theta KT} - \alpha\theta C_2(1-K)T + \theta C_2 - \;\; \alpha(C_1 + C_4\theta)]e^{\alpha KT} \quad (4.22)$$

$$\frac{\partial^2}{\partial K\,\partial T}(AVC) = \frac{\lambda_0}{\theta}\left[(\alpha+\theta)(C_1 + C_4\theta)Ke^{\theta KT}\right.$$

$$\left. - \{\alpha(C_1 + C_4\theta)K + C_2\theta(1-K)(\alpha KT + 1)\}\right]e^{\alpha KT} \qquad (4.23)$$

The Optimal value of T* of T and K* of K are obtained by solving (4.18) and (4.20).

The sufficient conditions that these values minimize AVC (T,.K) are

$$\frac{\partial^2}{\partial T^2}(AVC) > 0; \qquad \frac{\partial^2}{\partial K^2}(AVC) > 0 \qquad (4.24)$$

and

$$\frac{\partial^2}{\partial T^2}(AVC).\frac{\partial^2}{\partial K^2}(AVC) - \left(\frac{\partial^2}{\partial K\,\partial T}(AVC)\right)^2 > \; 0 \qquad (4.25)$$

Equations (4.18) and (4.20) can only be solved with the help of a computer oriented numerical technique for a given set of parameter values. Once T* and K* are obtained, we get t_1* from (4.5). We may then use (4.6) to determine the optimal EOQ I_0* and (4.14) to get the optimal average cost AVC*.

5. ILLUSTRATIVE EXAMPLES

Example1:

C_1=.001, C_2=5.0, C_3=10.0, C_4=4.0, α=0.53, λ_0=0.126

θ=0.05 in appropriate units.

Equations (4.18) and (4.20) are now solved using above data. Based on these input data, the computer outputs are as follows:

K*=.95909, T*=2.4403, t_1*=2.3405,

I_0* = .6909, AVC* = 58.3631 (5.1)

Computer oriented technique provides

$$\frac{\partial^2}{\partial K^2}(AVC) \;\; = 5.5551 \qquad \frac{\partial^2}{\partial T^2}(AVC) = 1.4136$$

and

$$\frac{\partial^2}{\partial K\,\partial T}(AVC) = 0.0053 \qquad (5.2)$$

at K=K* and T=T*

obviously (4.24) and (4.25) are satisfied. The value AVC* is minimal.

Example2:

C_1=.001, C_2=6.0, C_3=15.0, C_4=4.0, α=0.62, λ_0=0.132

θ=0.07 in appropriate units.

Based on these input data, the computer outputs are as follows:

K*=.95141, T*=2.5650 t_1*=2.4404 (5.3)

I_0* = .7395 AVC* = 91.9197 in appropriate units.

Corresponding to K= K* and T=T*, we have

$$\frac{\partial^2}{\partial K^2}(AVC) \;\; = 9.7363 \frac{\partial^2}{\partial T^2}(AVC) = 1.8665$$

and

$$\frac{\partial^2}{\partial K\, \partial T}(AVC) = 0.0153 \qquad (5.4)$$

The values are satisfied (4.24) and (4.25).

6. SENSITIVITY ANALYSIS

We now study the effects of changes in the values of the system parameters C_1, C_2, C_3, C_4, α, λ_0 and θ on the optimal cycle time, stock period, EOQ and Average variable cost derived by the proposed method. The sensitivity analysis is performed by changing each of the parameters by -50%, -20%, +20% and +50% taking one parameter at a time and keeping the remaining six parameters unchanged.

Table (Sensitivity Analysis)

Parameter	% change	% change in t_1*	% change in T*	% change in I_0*	% change in K*	%change in AVC*
C_1	-50%	-0.0490	-0.0385	-0.0579	-0.0104	-0.0691
	-20%	-0.0197	-0.0156	-0.0289	-0.0042	-0.0269
	+20%	0.0206	0.0164	0.0289	0.0042	0.0269
	+50%	0.0483	0.0389	0.0724	0.0094	0.0708
Parameter	% change	% change in t_1*	% change in T*	% change in I_0*	% change in K*	%change in AVC*
C_2	-50%	-29.3260	-34.8019	-38.5439	4.0622	13.9770
	-20%	-9.4385	-10.5893	-12.4041	1.0406	4.1177
	+20%	7.5749	8.2199	9.9580	-0.7027	-3.0533
	+50%	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter	% change	% change in t_1*	% change in T*	% change in I_0*	% change in K*	%change in AVC*
C_3	-50%	28.1902	28.2396	37.0531	-0.0688	57.6691
	-20%	9.5493	9.5710	12.5633	-0.0240	23.3744
	+20%	-8.1095	-8.1301	-10.6528	0.0191	-23.6571
	+50%	-18.3796	-18.4322	-24.1569	0.0444	-59.5268

Parameter	% change	% change in t_1*	% change in T*	% change in I_0*	% change in K*	%change in AVC*
C_4	-50%	-0.8294	1.2212	-1.0855	-2.0759	-17.7114
	-20%	-0.3331	0.4835	-0.4342	-0.8206	-7.0378
	+20%	0.3385	-0.4713	0.4487	0.8060	6.9763
	+50%	0.8517	-1.1630	1.1290	1.9915	17.3222
Parameter	% change	% change in t_1*	% change in T*	% change in I_0*	% change in K*	%change in AVC*
α	-50%	3.1186	3.1267	-21.9858	-0.0083	-0.5498
	-20%	-1.6718	-1.6760	-8.5975	0.0042	-0.8905
	+20%	2.9298	2.9369	6.6580	-0.0073	1.2165
	+50%	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter	% change	% change in t_1*	% change in T*	% change in I_0*	% change in K*	%change in AVC*
λ_0	-50%	-32.1494	-32.2542	28.8754	0.0792	-118.9263
	-20%	-9.9601	-9.9865	9.5383	0.0240	-29.1760
	+20%	7.8341	7.8523	-7.6422	-0.0198	19.0922
	+50%	17.0289	17.0635	-16.4134	-0.0417	37.7321
Parameter	% change	% change in t_1*	% change in T*	% change in I_0*	% change in K*	%change in AVC*
θ	-50%	-0.7677	1.3437	-2.1277	-2.1402	3.9318
	-20%	-0.3312	0.5245	-0.8540	-0.8602	1.5577
	+20%	0.3503	-0.5176	0.8684	0.8634	-1.5705
	+50%	0.9093	-1.2859	2.1277	2.1674	-3.9453

A careful study of above table1 reveals the following:

(i) K*, T*, t_1*, I_0* and AVC* increase (decrease) with increase (decrease) in the value of parameters C_1. However K*, T*, t_1*, I_0* and AVC* are slightly sensitive to changes in C_1.

(ii) T*, t_1*and I_0* increase (decrease) with the increase (decrease) in the value of parameters C_2, whereas K* and AVC* increase (decrease) with decrease (increase) in the value of C_2. However T*, t_1*and I_0* are moderately sensitive and K*, AVC* are slightly sensitive to changes in C_2.

(iii) T*, t_1*, I_0* and AVC* increase (decrease) with the decrease (increase) in the value of parameter C_3. Whereas K* increase (decrease) with the increase (decrease) in the value of C_3. However T*, t_1*, I_0* and AVC* are moderately sensitive and K* is slightly sensitive towards changes in C_3.

(iv) K*, t_1*, I_0* and AVC* increase (decrease) with the decrease (increase) in the value of parameter C_4 whereas T* decrease (increase) with the increase (decrease) in the value of C_4. However AVC* is moderately sensitive and K*, T*, t_1* and I_0* are slightly sensitive towards changes in C_4.

(v) K* and I_0* increase (decrease) with the increase (decrease) in the value of parameter α. whereas T*, t_1* and AVC* decrease (increase) with the increase (decrease) in the value of α. However I_0* is moderately sensitive and K*, T*, t_1* and AVC* are slightly sensitive towards the changes in α.

(vi) T*, t_1* and AVC* increase (decrease) with increase (decrease) in the value of parameter λ_0 whereas K* and I_0* decrease (increase) with increase (decrease) in the value of λ_0. However T*, t_1*, I_0* and AVC* are moderately sensitive and K* is almost insensitive towards changes in λ_0.

(vii) K*, T*, t_1*, I_0* increase (decrease) with increase (decrease) in the value of parameter θ whereas AVC* increase (decrease) with the decrease (increase) in the value θ. However K*, T*, t_1*, I_0* and AVC* are slightly sensitive towards changes in θ.

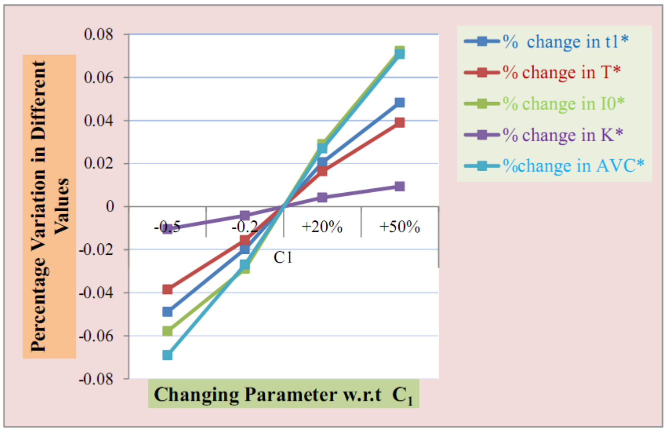

Fig 1 Percentage Variation in Parameter C_1

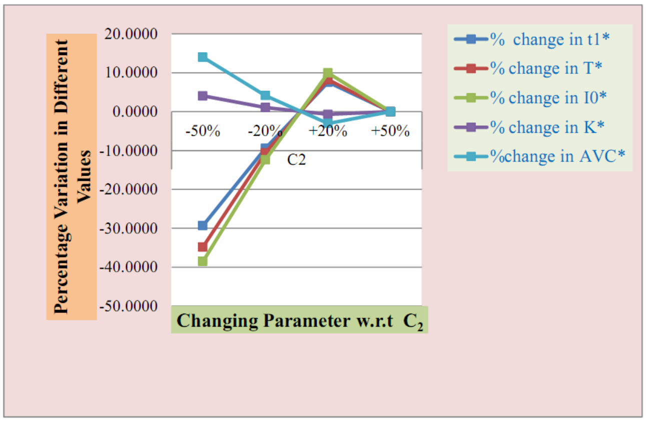

Fig 2 Percentage Variation in Parameter C_2

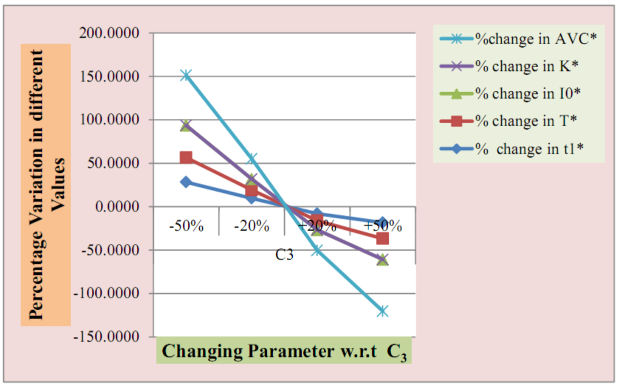

Fig 3 Percentage Variation in Parameter C_3

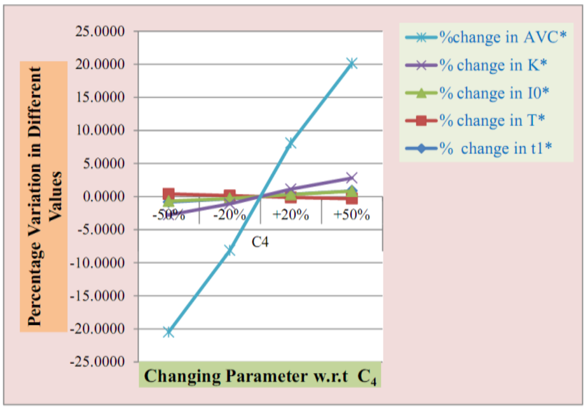

Fig 4 Percentage Variation in Parameter C_4

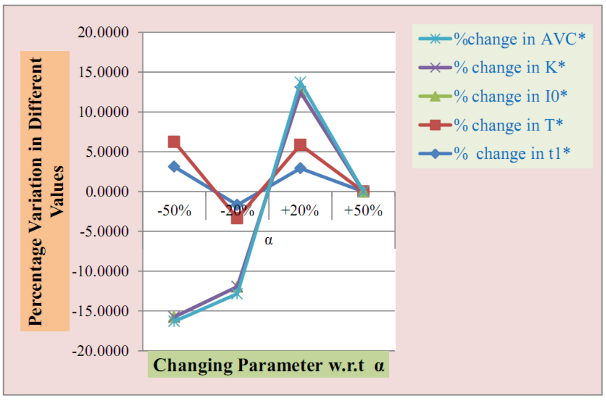

Fig 5 Percentage Variation in Parameter α

Fig 6 Percentage Variation in Parameter λ_0

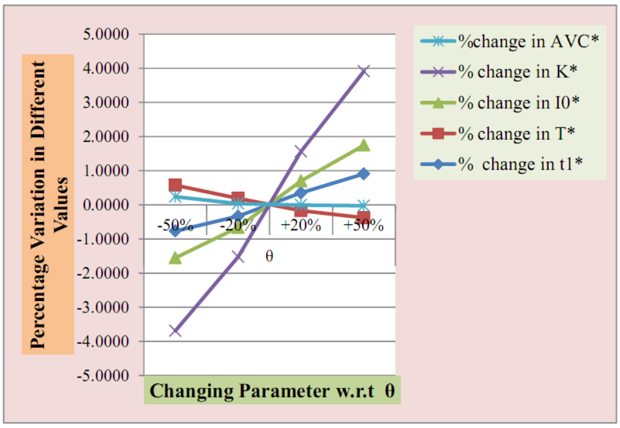

Fig 7 Percentage Variation in Parameter θ

7. CONCLUSION

The chapter is concerned with development of an inventory model for a deteriorating item with constant deteriorating rate having an instantaneous supply an exponential demand. Shortages are completely backlogged. The analytical approach is considered to obtain the optimal solution to minimise the average variable cost per time unit of the inventory system. It is illustrated with the help of numerical examples. Computer Oriented techniques is applied to solve the numerical problem. The effect of changes in the values of different parameters on the decision variable is studied.

REFERENCES

1. Ajanta Roy: *An Inventory model for deteriorating items with price dependent demand and time–varying holding cost*. Advanced Modeling and Optimization, 10, 2008,1

2. Bahari-Kashani, H.: *Replenishment schedule for deteriorating items with time-proportional demand*. Journal of Operational Research Society, 40, 1989, 75-81.

3. Chung, K. J., and Ting, P. S.: *A heuristic for replenishment of deteriorating items with a linear trend in demand*. Journal of Operational Research Society, 44(12), 1993, 1235-1241.

4. Dave, U. and Patel, L. K.: *(T, Si) policy inventory model for deteriorating items with time proportional demand*. Journal of Operational Research Society, 32, 1981, 137-142.

5. Deb, M. and Chaudhuri, K.: *A note on the heuristic for replenishment of trended inventories considering shortages*. Journal of Operational Research Society, 38, 1987, 459-463.

6. Dave, U.: *On a heuristic inventory replenishment rule for items with a linearly increasing demand incorporating shortages*. Journal of Operational Research Society, 40, 1989, 827-830.

7. Goyal, S. K.: *On improving replenishment policies for linear trend in demand*. Engineering Costs and Production Economics, 10, 1986, 73-76.

8. Goyal, S. K.*: A heuristic for replenishment of trended inventories considering shortages.* Journal of Operational Research Society, 39, 1988, 885-887

9. Goswami, A. and Chaudhuri, K. S.: *An EOQ model for deteriorating items with a linear trend in demand*. Journal of Operational Research Society, 42(12), 1991, 1105-1110.

10. Hariga, M.: *The inventory lot-sizing problem with continuous timevarying demand and shortages*. Journal of Operational Research Society, 45(7), 1994, 827-837.

11. Hariga, M.: *Optimal EOQ models for deteriorating items with time varying demand*. Journal of Operational Research Society, 47, 1996, 1228-1246.

12. Hariga, M.: *An EOQ model for deteriorating items with shortages and time-varying demand.* Journal of Operational Research Society, 46, 1995, 398-404.

13. Jalan, A. K., Giri, R. R. and Chaudhuri, K. S.: *EOQ model for items with Weibull distribution deterioration, shortages and trended demand*. International Journal of System Science, 27(9), 1996, 851-855.

14. Jalan, A. K. and Chaudhuri, K. S.: *Structural properties of an inventory system with deterioration and trended demand*. International Journal of System Science, 30(6), 1999, 627-633.

15. Murdeshwar, T. M.: *Inventory replenishment policies for linearly increasing demand considering shortages,* Journal of Operational Research Society, 39,1988, 687-692.

16. Ritchie, E.: *Practical inventory replenishment policies for a linear trend in demand followed by a period of steady demand*. Journal of

Operational Research Society, 31, 1980, 605-613.

17. Ritche Ritchie, E.: *The EOQ for linear increasing demand, a simple optimal solution.* Journal of Operational Research Society, 35, 1984, 949-952.

18. Sachan, R. S.: *On (T, Si) policy inventory model for deteriorating items with time proportional demand*. Journal of Operational Research Society, 35, 1984, 1013-1019.

19. S.K.Ghosh and K.S.Chaudhuri.: *An order-level inventory model for a deteriorating item with Weibull Distribution Deterioration, Time-quadratic demand and Shortages*. AMO, 6, 2004,1

20. Xu, H. and Wang, H.: *An economic ordering policy model for deteriorating items with time-proportional demand*. European Journal of Operational Research, 24, 1991, 21-27.