Inventory Model for Deteriorating Items with Stock Dependent Demand under the Effect of Inflation and Trade Credit Period

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ABSTRACT
In this study a deterministic inventory model for deteriorating items with stock dependent demand is developed. In this model the shortages are allowed and partially backlogged and the effect of inflation rate and delay in payments are discussed. This paper establishes an inventory model for the deteriorating items and stock dependent demand rate under inflation when the supplier offers a permissible delay to the purchaser. Then an optimal solution is obtained to find the relevant total optimal cost in two cases.

CASE-1: In this case, the length of the period with the positive inventory of items is longer than the credit period.

CASE-2: In this case, the permissible delay is longer than the length of the period with the positive inventory of items . The interest of purchasing cost is charged for the delay of payments by the retailers. In both the cases the total average inventory cost per unit time is minimized.

Keywords
Stock dependent demand, deteriorating items, inflation rate, trade credit period, shortages and backlogging

1. INTRODUCTION
Inventory plays a vital role in business to ensure smooth efficient running of its operation. Large number of research papers/Articles has been presented by many authors for controlling the inventory of deteriorating items such as volatile liquids, blood banks, medicines, fashion goods and non-deteriorating items such as wheat, rice, dry fruits etc. The control and the maintenance of inventories of deteriorating items with shortages have received much attention of several researchers in the recent years because most physical goods deteriorate overtime. In practice, the deterioration of items is a common phenomenon. Hence the impact of product deterioration should not be neglected in the decision process. The retailer must pay off as soon as the items are received. It is tacitly assumed in classical economic order quantity inventory model, a supplier frequently offers his retailers a delay of payment for settling the amount due. The permissible delay in payment is an effective method of attracting new customers and increasing sales. It may be applied as alternative to price discount because it does not provoke the competitors to reduce their prices and thus introduce lasting price reductions. Goyal (1) first considered the Economic Order Quantity Model under the conditions of permissible delay in payments. Hu and Liu (2) (2010) analyzed An Optimal replenishment policy for the EPQ model with permissible delay in payments and allowable shortages. Huang (3) (2007) developed Economic Order Quantity to order goods under permissible delay in payments. Chang, Wu and Chen (4) (2009) studied Optimal Payment Time with Deteriorating Items under the Inflation and Permissible Delay in Payments.

Trade credit period produces two benefits to the supplier: 1. It will attract the new customers who consider it to be a type of price reduction. 2. It will cost the reduction in the sale outstanding since some established customer will order more and pay more promptly in order to take advantage of permissible delay more frequently. Chun-Tao Chang (5) developed An Inventory Model with Deteriorating Items for Constant Demand under Inflation and the Condition of Permissible Delay in Payments.

Inflation also plays an important role for the optimal order policy and influences the demand of certain products. The value of money goes down and erodes the future worth of saving and forces one for more current spending as inflation increases. The first Economic order quantity model by considering the effect of inflation was developed by Buza Cott(6) Suetal. He developed the model under the inflation of stocks dependent consumption rate and exponential decay. Most of the classical inventory model did not take into account the effects of inflation. This happened mostly because of the belief that the inflation would not influence the inventory policy variables to any significant rate. However most of the countries have suffered from large scale inflation and sharp decline in the purchasing power of money, the past few years. As a result the effect of inflation and time value of the money cannot be ignored for determining the optimal inventory policy.

Hou (7) studied An Inventory Model for Deteriorating Items with Stock Dependent Consumption Rate and Shortages under Inflation and Time Discounting. Hou and Lin(8) developed an EOQ Model for deteriorating items with price and stock dependent selling rates under inflation and time value of money. Mirzadesh, Syeed- Esfahani (9) analyzed An Inventory Model under Uncertain Inflationary Conditions, Final Production Rate and Inflation Dependent Rate for Deteriorating Items with Shortages.

Numerical examples and sensitivity analysis of parameters are given to illustrate the theoretical results.

2. NOTATIONS

H	The length of planning horizon
R(t)	Demand rate is deterministic(Stock Dependent demand)

T	The replenishment time interval
I(t)	The inventory level at time ‘t’, $0 \le t \le T$
i	Constant rate of inflation per unit time $0 \le i \le 1$
Pe^{it}	The unit purchasing cost at time ‘t’ where P is the unit purchasing cost at time zero.
h	The holding cost rate per unit time excluding interest charges.
S	Shortage cost, $ per unit/year.
Π	Opportunity cost due to lost sales $ per unit.
Ke^{it}	The ordinary cost per order at time t where K is the ordering cost at time zero.
I_e	The interest earned per $ per year.
I_r	Interest charges which invested in inventory per $ per year $I_r \ge I_e$.
T	Length of the replenishment cycle.
T_1	Time at which the shortage starts $0 \le T_1 \le T$.
Q	The order quantity.
θ	The Constant rate of deterioration $0 \le \theta \le 1$.
n	number of replenishments during the period H [H= nT]
TVC(T_1, T)	The Average total inventory cost per unit time.
$TVC_{1,}(T_1,T)$	The average total inventory cost per unit time for $T_1 > M$ in case (1).
TVC_2 (T_1,T)	The average total inventory cost per unit time for $T_1 < M$ In case.(2)

3. ASSUMPTIONS

1. The demand rate functions R(t) is deterministic and is known as the function of the instantaneous stock level . The functional R(t) is given by

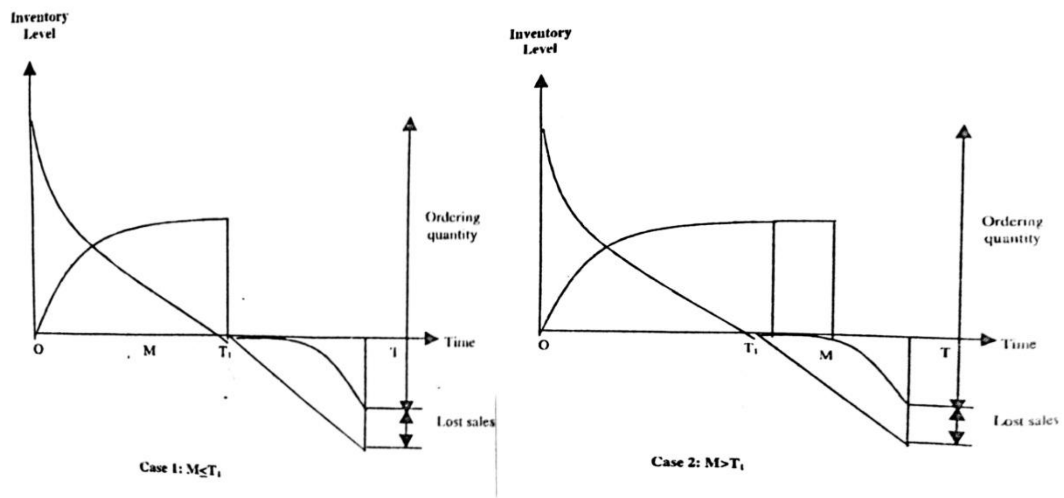
   $$R(t) = \begin{Bmatrix} \alpha + \beta I(t)\ ;\ 0 \le t < T_1;\ \alpha > 0 \\ \alpha\ ;\ T_1 \le t < T \end{Bmatrix}$$

2. Inflation rate is constant.
3. The replenishment rate is infinite.
4. There are no replacements or repair of deteriorated units.
5. Shortages are allowed and partially backlogged. The backlogged rate is defined to be $\frac{1}{1+\delta(T-t)}$.

   When inventory is negative, the backlogging parameter δ is a positive constant.
6. During the trade credit period , if the account is not settled , the generated sales revenue is deposited in an interest bearing account. At the end of the permissible delay, the customer pays off all the units ordered and starts paying for the interest charges on the items in stock.

4. MATHEMATICAL FORMULATION

Due to the combined effects of demand and deterioration in the interval [0,T] the level of inventory gradually decreases.



Graphical Representation of Inventory System

Hence the variation of inventory with respect to time can be described by the following differential equation.

$$\frac{dI(t)}{dt} + \theta\, I(t) = -\alpha - \beta I(t) \quad 0 \le t \le T_1 \quad \ldots \quad (I)$$

With the boundary conditions :
$I(0) = Q$

$I(T_1) = 0$

Solution of equation (I) is

$I(t)\, e^{(\theta+\beta)t} = -\alpha \int e^{(\theta+\beta)t} dt + C$

$$= \frac{-\alpha e^{(\theta+\beta)t}}{(\theta+\beta)} + c \qquad \text{(II)}$$

Using the boundary condition $I(T_1) = 0$, $I(T_1)\, e^{(\theta+\beta)T_1} = \frac{-\alpha e^{(\theta+\beta)T_1}}{(\theta+\beta)} + c$

Therefore $C = \frac{\alpha e^{(\theta+\beta)T_1}}{(\theta+\beta)}$

$I(T_1)\, e^{(\theta+\beta)t} = -\frac{\alpha e^{(\theta+\beta)t}}{(\theta+\beta)} + \frac{\alpha e^{(\theta+\beta)T_1}}{(\theta+\beta)}$

Dividing by $e^{(\theta+\beta)t}$,

$$I(t) = \frac{-\alpha}{\theta+\beta)} + \frac{\alpha e^{(\theta+\beta)(T_1-t)}}{(\theta+\beta)}$$

$$= \frac{\alpha}{\theta+\beta)} [\, e^{(\theta+\beta)((T_1-t)} - 1] \;;\; 0 \le t < T_1 \qquad ..(1)$$

Now by using the boundary conditions $I(0) = Q$ in the solution:

$$Q = [\frac{\alpha}{\theta+\beta}] \left[e^{(\theta+\beta)T_1)} - 1\right] \qquad ......(*)$$

Consider $T_1 \le t < T$

$$\frac{dI(t)}{dt} = \frac{-\alpha}{1+\delta(T-t)} \qquad .(III)$$

By solving the above equation

$$I(t) = -\alpha \, \log[1 + \delta(T-t)] \left(\frac{-1}{\delta}\right) + C$$

Where c is the constant of integration.

Using the given boundary condition $I(t)$ as follows

$$I(t) = -\frac{\alpha}{\delta} \{\log[1 + \delta(T - T_1] - \log[1 + \delta(T - t)]\}$$

$$I(t) = \left(\frac{\alpha\theta-\beta}{\theta^2}\right) \left[e^{\theta(T_1-t)} - 1\right] + \frac{\beta}{\theta}\left[T_1 e^{\theta\,(T_1-t)} - t\right] \; when\; 0 \le t < T_1$$

$$I(t) = -\frac{\alpha}{\delta} \{\log[1 + \delta(T - T_1] - \log[1 + \delta(T - t)]\}$$

$$when\;\; T_1 \le t < T \ldots\ldots\ldots\ldots\ldots(3)$$

Since the length and time intervals are all the same,

$$I(jt+T) = \begin{cases} \frac{\alpha}{\theta+\beta}\left[e^{(\theta+\beta)(T_1-t)} - 1\right] \\ for \quad 0 \le j \le n-1; 0 \le t \le T_1 \qquad ....(3) \\ \frac{-\alpha}{\delta}\{\log(1+\delta(T-T_1)) - \log[1+\delta(T-t)]\} \\ for \quad T_1 \le t \le T; 0 \le j \le n-1. \qquad ...(4) \end{cases}$$

The total relevant costs consists of

a. Cost of placing order.

b. Cost of purchasing.

c. Cost of carrying inventory excluding interest charges.

d. Shortage cost.

e. Opportunity cost.

f. The cost of interest charges for unsold items at the initial time or after permissible delay M.

g. The interest earned from sales revenue during the permissible period.

Cost of placing order:

$K(0) + K(T) + K(2T) + \ldots\ldots\ldots + K(n\text{-}1)T$

$= Ke^{i0} + Ke^{iT} + Ke^{i2T} + \ldots\ldots\ldots\ldots + Ke^{i(n-1)T}$

$= K\left[\frac{e^{iH}-1}{e^{ij}-1}\right]$

Cost of purchasing :-

$Q\left[Pe^{io} + Pe^{iT} + \ldots\ldots\ldots\ldots\ldots + Pe^{i(n-1)T}\right]$

$= \left[\frac{P\alpha}{\theta+\beta}\right]\left[e^{(\theta+\beta)T} - 1\right]\left[\frac{e^{iH}-1}{e^{iT}-1}\right]$

Holding cost in the interval [0,T] is(for one cycle)

$Hc = h\int_0^{T_1} I(t)dt$

$= h\int_0^{T_1} \frac{\alpha}{\theta+\beta}\left[e^{(\theta+\beta)(T_1-t)} - 1\right] dt$

$$= \frac{h \propto [e^{(\theta+\beta)T_1} - 1 - \theta T_1 - \beta T_1]}{(\theta+\beta)^2}$$

Holding Cost For N Cycles Is

$Hc = h\sum_{j=0}^{n-1} Pe^{ijt} \int_0^{T_1}[I(jT+t)]\, dt$

$Hc = h\sum_{j=0}^{n-1} Pe^{ijt} \int_0^{T_1}\left[e^{(\theta+\beta)(T_1-t)} - 1\right] dt$

$= \left[\frac{hP\alpha}{(\theta+\beta)^2}\right]\left[e^{(\theta+\beta)T_1} - (\theta+\beta)T_1 - 1\right]\left[\frac{e^{iH}-1}{e^{iT}-1}\right]$

Deterioration cost in the interval $[0, T_1]$

$= P\theta\int_0^{T_1} I(jT+t)dt$

$= P\theta\int_0^{T_1} \frac{\alpha}{(\theta+\beta)}\left[e^{(\theta+\beta)(T_1-t)} - 1\right]dt$

$$= \frac{P\,\theta \propto [e^{(\theta+\beta)T_1} - 1 - \theta T_1 - \beta T_1]}{(\theta+\beta)^2}$$

Therefore for n cycles

$= \frac{P\theta\alpha(e^{(\theta+\beta)T_1} - 1 - \theta T_1 - \beta T_1)}{(\theta+\beta)^2}\left[\frac{e^{iH}-1}{e^{iT}-1}\right]$

During the stock out period two kinds costs to be considered. First to derive the shortage cost for the backlogged items and then to obtain the opportunity cost due to lost sales. The shortage cost over the period $[T_1,T)$ denoted by SC is given by:

(i.e) Shortage is given by

$SC = S\int_{T_1}^{T} I(t)dt$

substitute (4) in I(t)

$= S\sum e^{ijt}\int_{T_1}^{T}\frac{-\alpha}{8}\{\log(1 + \delta(T-T_1) - \log[1 + \delta(T - t)]\}dt$

Therefore on simplification

SC = $\sum e^{ijt}\left(\frac{-S\propto}{8}\right)\Big\{(T-T_1)\log(1+\ \delta(T-T_1)-(T-T_1)\log[1+\delta(T-T_1)]\ +\ (T-T_1)\ \frac{-1}{\delta}\log(1+\delta(T-T_1)\Big\}$

$= -\sum e^{ijt}\frac{S\propto}{\delta}\ \{\ \delta(T-T_1)-\log[1+\delta\ (T-\ T_1)]\ \}$

The cost cannot be negative, so the shortage cost is given for 'n' cycles:-

Sc = $\frac{S\propto}{\delta^2}\ \{\ \delta(T-T_1)-\log[1+\delta(T-T_1)]\ \left[\frac{e^{iH}-1}{e^{iT}-1}\right]$

Now the opportunity cost due to lost sales during the replenishments cycle denoted by OC is given by.

OC = $\sum e^{ijt}\Pi\int_{T_1}^{T}\propto[1-\frac{1}{1+\delta(T-t)}]$ dt

$=\sum e^{ijt}\frac{\Pi\propto}{\delta}\ \{\ \delta(T-T_1)-\log[1+\ \delta\ (T-T_1)]$

$=\ \frac{\Pi\propto}{\delta}\delta(T-T_1)-\log[1+\ \delta\ (T-T_1)]\ \left[\frac{e^{iH}-1}{e^{iT}-1}\right]$

Now consider M which is the permissible delay in settling the accounts offered by the supplier.

Case 1 : M≤ T_1

Since in this case the length of the period with positive inventory is longer than the credit period, the buyer can earn the interest with an annual rate I_e in $[0,T_1)$.

Now the interest earned is denoted by IE_1 is given by

$IE_1 = PI_e\sum_{j-0}^{n-1}e^{ijt}\int_0^{T_1}(T_1-t)\,R(t)dt$

$= PI_e\ .\sum_{j-0}^{n-1}e^{ijt}\ \int_0^{T_1}(T_1-t)\Big[\alpha+\ \ \beta\frac{\alpha}{\theta+\beta}\ [e^{(\theta+\beta)(T_1-t)}-1]\Big]$dt

The interest charged in (0,H) is after the fixed credit period. The buyer has to pay interest on the product still in stock with an annual rate I_r:I_p

Therefore $I_p = I_r\sum_{j=0}^{n-1}Pe^{ijt}\int_M^{T_1}I(jT+t)dt$

$= P\ I_r\sum_{j=0}^{n-1}e^{ijt}\int_M^{T_1}\frac{\alpha}{\theta+\beta}\left[e^{(\theta+\beta)(T_1-t)}-1\ \right]dt$

The total average cost in this case is

$TVC_1 = \frac{1}{T}\ [\ K+HC+DC+SC+OC+IP-IE_1]$

$=\frac{1}{T}\left[K+\frac{hp\alpha}{(\theta+\beta)^2}\left(e^{(\theta+\beta)T_1}-(\theta+\beta)\,T_1-1\right)\right]+P\theta\alpha\ \frac{[e^{(\theta+\beta)T_1}-1-\theta T_1-\beta T_1]}{(\theta+\beta)^2}+\frac{S\alpha}{\delta^2}\ \{\delta(T-T_1)-\ \log[1+\delta(T-T_1)]\}+\frac{\pi\alpha}{\delta}\ \{\{\delta(T-T_1)-\ \log[1+\ \delta(T-T_1)]\}\}+IP_1-IE_1]\left[\frac{e^{iH}-1}{e^{iT}-1}\right]$

The total average cost per unit time can be minimized on the optimal values of T_1 and T i.e (T_1^* & T^*) can be found by solving the following equations.

$\frac{\partial TVC_1(T,T)}{\partial T_1} = 0$ ---(A) ; $\frac{\partial TVC_1(T,T)}{\partial T} = 0$ -----(B)

Provided they satisfy the sufficient conditions:

$$\left[\frac{\partial^2 TVC_1(T_1,T)}{\partial T_1^2}\right]>0$$

$$\left[\frac{\partial^2 TVC_1(T_1,T)}{\partial T^2}\right]>0$$

$$\left[\left[\frac{\partial^2 TVC_1(T_1,T)}{\partial {T_1}^2}\right]\left[\frac{\partial^2 TVC_1(T_1,T)}{\partial T^2}\right]-\ [\frac{\partial^2 TVC_1(T_1,T)}{\partial T_1\,\partial T}]^2\right]\quad >\ 0$$

To find the optimal values of T_1 and T use the following algorithm

Algorithm:

Step-1 :perform(1) – (4)

1. Start with $T_1(1)$ = M.
2. Substituting T_1 into equation (A) and find $T_{(1)}$.
3. Using $T_{(1)}$find $T_{(2)}$ form equation.(B).
4. Repeat (2) and (3) until no change occurs in the value of T_1 and T.

Step -2: Compare T_1 and M

(i) If M ≤ T_1 , $T_1$is feasible then go to step 3.

(ii) If M > T_1 , T_1 is not feasible, set T_1= M and find the corresponding value of T from (B) then go to step 3.

Step-3:

Calculate corresponding TVC, (T_1^*, T^*)

Case 2: M > T_1

Since T_1 < M the buyer earns the interest during the period (O,M) and pays no interest.

The interest earned in this case is denoted by IE_2 is given by

$IE_2 =\sum_0^{n-1}\ e^{ijT}$P. Ie $\left\{\int_0^{T_1}(M-t)R(t)\,dt\right.$ $[R(t)\ is\ from\ (1)]$

$=\sum_0^{n-1}\ e^{ijT}$P. Ie $\int_0^{T_1}(M-T_1+\ T_1-t)(\alpha+\beta I(t))dt)$

$=\sum_0^{n-1}\ e^{ijT}$ P.Ie $\int_0^{T_1}(T_1-t)\left[\alpha+\beta\left(\frac{\alpha}{\theta+\beta}\right)\left\{e^{(\theta+\beta)(T_1-t)}-1\right\}\right]dt+\sum_0^{n-1}\ e^{ijT\cdot}$ P.Ie . $\int_0^{T_1}(M-\ T_1)\left[\alpha+\beta\ \left(\frac{\alpha}{\theta+\beta}\right)\left\{e^{(\theta+\beta)(T_1-t)}-1\right\}\right]\ dt$

Therefore the total average cost in the case is

$TVC_2 = \frac{K+HC+DC+SC+OC-IE_2}{T}$

$=\frac{1}{T}\left(K+\frac{hp\alpha}{(\theta+\beta)^2}\left(e^{(\theta+\beta)T_1}-(\theta+\beta)\,T_1-1\right)+P\theta\alpha\ \frac{[e^{(\theta+\beta)T_1}-\theta T_1-\beta T_1-1]}{(\theta+\beta)^2}+\frac{S\alpha}{\delta^2}\ \{\delta(T-T_1)-\ \log[1+\delta(T-T_1)]\}+\frac{\pi\alpha}{\delta}\ \delta(T-T_1)-\ \log[1+\ \delta(T-T_1)]-IE_2\right)\left[\frac{e^{iH}-1}{e^{iT}-1}\right]$

For minimising the total average inventory cost per unit time, it is necessary to find the optimal value of T_1 and T which are the solutions of the following equations

$\frac{\partial\ TVC_2\,(T_1,T)}{\partial T_1}=0$ ------(C)

$\frac{\partial\ TVC_2\,(T_1,T)}{\partial T}=0$ ------(D)

$\left[\frac{\partial^2 TVC_1(T,T)}{\partial T_1^2}\right] > 0; \left[\frac{\partial^2 TVC_1(T,T)}{\partial T^2}\right] > 0$

$$\left[\left[\frac{\partial^2 TVC_2(T,T)}{\partial T_1^2}\right]\left[\frac{\partial^2 TVC_2(T_1,T)}{\partial T^2}\right] - \left[\frac{\partial^2 TVC_2(T_1,T)}{\partial T_1\, \partial T}\right]^2\right] > 0$$

To find the optimal values of T_1 and T use the following algorithm.

Algorithm:

Step-1: perform(1) – (4)

5. Start with $T_1(1) = M$.
6. Substituting T_1 into equation (C) and find $T_{(1)}$.
7. Using $T_{(1)}$find $T_{(2)}$ form equation.(D).
8. Repeat (2) an d (3) until no change occurs in the value of T_1 and T.

Step -2: Compare T_1 and M

(i) If $M \le T_1$, $T_1$is feasible then go to step 3.

(ii) If $M > T_1$, T_1 is not feasible, set T_1= M and find the corresponding value of T from (D) then go to step 3.

Step-3:

Calculate corresponding $TVC_2\,(T_1^*, T^*)$

5. NUMERICAL EXAMPLES

Example-1

Let H = 1 year , α = 1000, β =0.3; h= 1.2, P= 20, k=100; S = 30; δ = 1 ; I_r= 0.15, I_e = 0.13; θ= 0.08, M = 2/365; i= 0.03; π=15; n=2

From the table 1, if K increases from 100 to 250, the total average cost increases. As K increases the total average cost also increases

Table1: Sensitivity analysis on K

K	CASE-I			CASE-II			TVC
	T^*	T_1^*	TVC_1	T^*	T_1^*	TVC_2	Min (TVC_1, TVC_2)
100	0.1100	0.0707	3620.24	0.1071	0.0660	3718.26	3620.24
150	0.1346	0.0857	4440.84	0.1310	0.0807	4561.14	4440.84
200	0.1554	0.0989	5133.41	0.1512	0.0932	5272.64	5133.41
250	0.1737	0.1105	5744.14	0.1690	0.1041	5900.18	5744.14

Example 2:

Let H = 1 year , α = 1000, β =0.3; h= 1.2, P= 20, k=200; S = 30; δ = 1 ; I_r= 0.15, I_e = 0.13;

θ= 0.08, M =2/365; i= 0.03; π=15; n=2

From the table 2, if M increases from 100 to 250 , the total average cost decreases.

Table 2: Sensitivity analysis for M:

M	CASE I			CASE II			TVC
	T^*	T_1^*	TVC_1	T^*	T_1^*	TVC_2	Min (TVC_1, TVC_2)
5	0.1555	0.0993	5104.88	0.1512	0.0935	5245.77	5104.88
10	0.1558	0.1001	5104.88	0.1513	0.0945	5200.81	5104.88
15	0.1563	0.1010	5027.83	0.1513	0.0945	5155.60	5027.83
20	0.1571	0.1020	4999.60	0.1513	0.0950	5110.14	4999.60

Example-3:

Let H = 1 year , α = 1000, β =0.3; h= 1.2, P= 20, k=200; S = 30; δ = 1 ; I_r= 0.15, I_e = 0.13; θ= 0.08, M = 2/365; i= 0.05; π=15; n=2. From the table 3, if i increases from 0.05,0.10,0.15, 0.20 , the total average cost increases

Table 3: Sensitivity analysis for i:

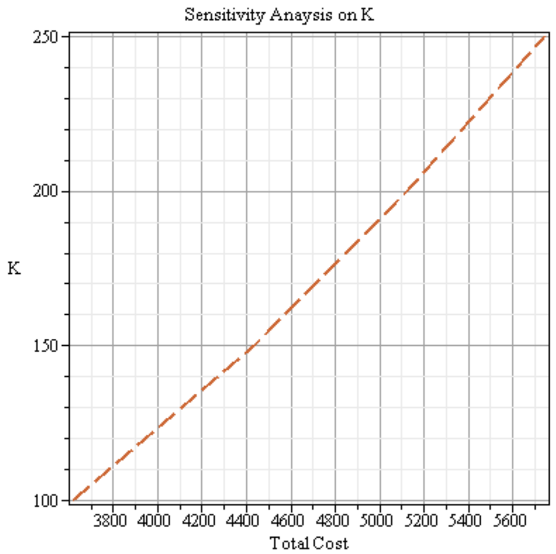
I	CASE-I			CASE-II			TVC
	T^*	T_1^*	TVC_1	T^*	T_1^*	TVC_2	Min (TVC_1, TVC_2)
0.05	0.1549	0.0986	5149.07	0.05	0.1549	0.0986	5149.07
0.10	0.1538	0.0979	5187.62	0.10	0.1538	0.0979	5187.62
0.15	0.1528	0.0972	5225.33	0.15	0.1528	0.0972	5225.33
0.20	0.1518	0.0966	5262.27	0.20	0.1518	0.0966	5262.27

Example 4:
Let H = 1 year , α = 1000, β =0.3; h= 1.2, P= 20, k=200; S = 30; δ = 1 ; I_r= 0.15, I_e = 0.13; θ= 0.08, M = 2/365; i= 0.05; π=15; n=2. From the table 4, if δ increases from 1,2,3,4 the total average cost increases.

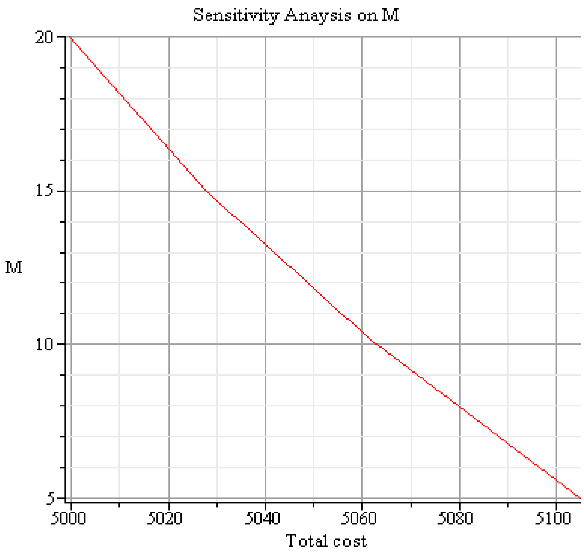
Table 4: Sensitivity analysis for δ:

δ	CASE –I			CASE-II			TVC
	T^*	T_1^*	TVC_1	T^*	T_1^*	TVC_2	Min (TVC_1, TVC_2)
1	0.1554	0.0989	5133.41	1	0.1554	0.0989	5133.41
2	0.1482	0.1037	5382.84	2	0.1482	0.1037	5382.84
3	0.1437	0.1070	5551.27	3	0.1437	0.1070	5551.27
4	0.1406	0.1904	5672.79	4	0.1406	0.1904	5672.79

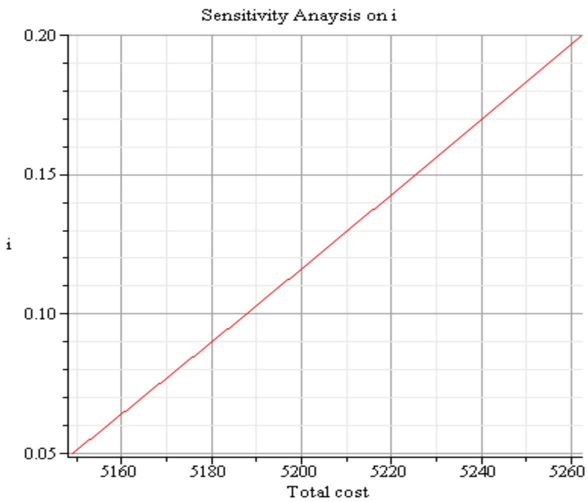
Graph For sensitivity analysis for K:



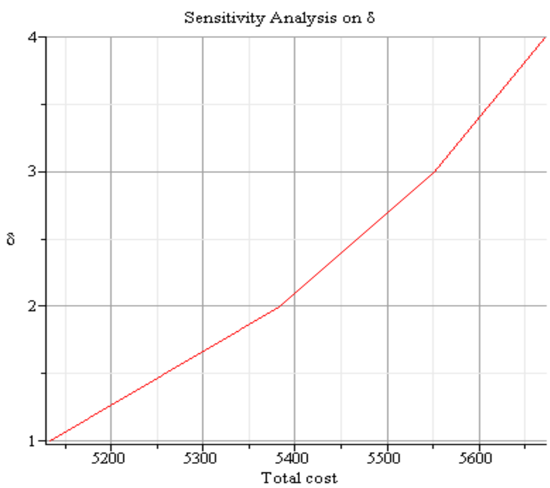
Graph for sensitivity analysis on M:



Graph for sensitivity analysis on i:



Graph for Sensitivity analysis on δ:



5.1 Managerial Implications

Based on the numerical examples considered above, the effects of change of K, M, δ, i on the optimal values of the total average cost is studied.

1. In example 1, different values of K are considered. The computed results are shown in the Table 1. From these computed results, it is inferred that a higher value of ordering cost K implies higher total cost. Hence the retailer should lessen the ordering cost.
2. In example 2, the problem with various values of M are analyzed. Table 2 gives a clear picture that as the credit period increases, the total cost decreases. So the supplier's permissible delay makes the retailer very lucrative i.e., the retailer is most beneficiary if he gets longer permissible delay period from the supplier.
3. In example 3, the effects of inflation rate is studied. The results are given the table 3. From these results, a higher value of inflation rate implies larger value of the total average cost .
4. In example 4, M and K are fixed and different values of δ are considered. The results are given in the table. As the value of the δ increases the total average cost also increases. It is implied that the retailer should restrict the backlogging parameter with the aim of reducing the average total inventory cost.

6. CONCLUSION

This paper presents an inventory model of direct application to the business that considers the fact that the storage items are deteriorated during storage periods. The model allows for shortages and the demand is partially backlogged. The objective of our model is to minimize the retailer's total inventory cost through various parameters like permissible delay in payments, inflation rate and ordering cost. The model is solved analytically by minimizing the total inventory cost. Finally the proposed model has been verified by the numerical examples and graphical analysis.

In practical situations, the information about inventory is always precise, most of the time it is vague or imprecise. So it is more reasonable to develop an dynamic research method and is also the future trend of deteriorating inventory study. The model presented in this study provides a basis for several possible extensions. For future research, this model can be extended to accommodate planned shortages, variable costs, different rates of inflation, etc. This model is very practical for the retailers who use the preservation technology for deteriorating items. Sensitivity analysis proves that the total inventory cost can be reduced.

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