ISSN 2250-3153

Probabilistic inventory model for deteriorating items in presence of trade credit period using discounted cash flow approach

Neetu [1], Sapna Mahajan[2], Dr. Arun Kumar Tomer[3]

[1]P. G. Deptt. of Mathematics, APJ College of Fine Arts, Jalandhar, India
[2]Deptt. of Mathematics, ARNI University, Kathgarh, H.P, India
[3]P. G. Deptt. of Mathematics, SMDRSD College, Pathankot, India

Abstract- In this paper, we are using discounted cash flow approach for deteriorating items in the presence of trade credit period. Here it is assumed that the demand during the period (0, T) is a random variable x with continuous probability density function f(x) and the demand rate is a power demand pattern. Shortages are not allowed and deterioration follows the Weibull distribution rate. Mathematical models are derived for three different cases: Instantaneous cash flows, credit only on units in stock, fixed credit period. Inflation and time value of money is also considered.

***Index Terms*-** credit-period, deterioration, inventory, probabilistic

I. Introduction

Many authors have considered economic order quantity models for deteriorating items.Ghare & Schrader (1963) were the first who studied inventory models of deteriorating items. They assumed the constant market demand. With the passage of time several other researchers developed the inventory model for deteriorating items with time dependent demand rate. Donaldson (1997) derived an optimal algorithm for solving classical inventory model with no shortage analytically with linear trend in demand over fixed time horizon. Dutta and Paul (1997) considered the both deterministic and probabilistic version of power demand pattern with variable rate of deterioration. Hariga (1995) studied the effects of inflation and time value of money on an inventory model with time dependent demand and shortages. Bhunia et al (1998) developed an inventory model of deteriorating items with lot size dependent replenishment cost and linear trend in demand.

Generally it is assumed that the buyer must pay for the items as soon as he receives them from the supplier, but in reality supplier will allow a certain fixed period called credit period, for settling the amount the retailer owes to him for the items supplied. The credit period reduces the buyer's cost of holding stock because it reduce the amount of capital invested in stock for the duration of the permissible period. Chung (1989) used the discounted cash flows (DCF) approach for studying the optimal inventory policy in the presence of the trade credit, which permits an explicit recognition of the exact timing of cash flows associated with the inventory system.

A DCF approach permits a proper recognition of the financial implication of the opportunity cost and out of pocket costs in inventory system. Aggarwal and Jaggi (1994) analyzed the credit financing in economic ordering policies of deteriorating items in the presence of trade credit using a DCF approach. Liao et al. (2000) presented a model with deteriorating items under inflation, when delay in payments is permissible. Chang (2004) presented an EOQ model with deteriorating items under inflation when the supplier provides a permissible delay of payments for a large order that is greater than or equal to the pre-determined quantity. Shah and Shah (1998) presented a probabilistic inventory model with cost in case delay in payments is permissible. Chang et al. (2001) developed a finite time horizon inventory model with both deterioration and monetary time value when payment periods are offered. Huang and Chung (2003) discussed replenishment and payment policies to minimize the total cost of cash discount and payment delays. Huang (2003) considered an EOQ model in which supplier offers a credit period to retailer and retailer offers a credit period to the customers.

Demand also depends on the retailers sales efforts. This situation was discussed by Taylor (2002). He proved that coordination cannot be achieved with linear rebates and returns or target rebates alone. He provided a properly designed target rebate and returns contracts to get coordination. Krishanan et al. (2004) analysed the coordination of contracts for decentralized supply chains with the retailer promotional efforts. They found that a buy back policy cannot be utilized to coordinate the channels and they provided three contracts to achieve channel coordination. Liang et al. (2005) discussed an inventory model with non-instantaneous receipt under trade credit in which the supplier provides not only a permissible delay but also a cash discount to the retailer and obtained the optimal order cycle and orders receipt period so that the total relevant cost per unit time is minimized. Tripathi (2011) presented the economic ordering policies of time dependent deteriorating items in presence of trade credit using discounted cash flow approach. In the last model we have taken deterministic power demand. But, since in most of the practical situations, demand is not deterministic, rather it varies from cycle to cycle. Hence, we are considering the probabilistic version of demand. Effects of inflation and time value of money is also considered.

II. ASSUMPTIONS

1. Deterioration of items starts after a definite time.
2. Deterioration rate varies with time and follows a two parameter Weibull distribution.
3. Replenishment is instantaneous.
4. Lead time is zero.
5. Shortages are not allowed.
6. There is no repair or replacement of deteriorating items during the period under consideration.
7. Inflation and time value of money is considered.
8. The demand during the period (0, T) is a random variable *x* with continuous probability density function

f(*x*), $x \in (0, \infty)$ and demand rate is power demand pattern,

$D(t) = \frac{mx}{T^m} t^{m-1}$, where $m \in (0, \infty)$ is the pattern index.

III. NOTATIONS

1. 'C' is unit cost of the item.
2. 'Q' is the order quantity.
3. 'D(t)' is the demand rate at time 't.
4. 'i' is Inventory holding cost fraction.
5. 'iC' is the out-of-pocket inventory carrying cost per unit time.
6. 'R' is constant representing the difference between the discount rate and inflation rate.
7. 'H' is the ordering cost per unit.
8. I(t) is the inventory level at time t.
9. T_1 is the optimal cycle time for case I.
10. T_2 is the optimal cycle time for case II.
11. T_3 is the optimal cycle time for case III.
12. Z_1 (T) is the present value of all future cash-flows for case I.
13. Z_2 (T) is the present value of all future cash-flows for case II.
14. Z_3 (T) is the present value of all future cash-flows for case III.
15. Z_1 (T_1) is the optimal value of all future cash-flows for case I.
16. Z_2 (T_2) is the optimal value of all future cash-flows for case II.
17. Z_3 (T_3) is the optimal value of all future cash-flows for case III.
18. T is the inventory cycle time.

IV. MATHEMATICAL FORMULATION

The level of inventory I(t) at time 't' is depleted due to both market demand and deterioration. The differential equation describing the inventory system over (0, T) is given by

$$\frac{dI(t)}{dt} + \alpha\beta t^{\beta-1} I(t) = -\frac{mx}{T^m} t^{m-1}, \quad 0 \le t < T \qquad (1)$$

with the boundary condition, $I(T) = 0$

The solution of equation (1) is given by

$$I(t)e^{\alpha t^\beta} = -\int \frac{mx}{T^m} t^{m-1} e^{\alpha t^\beta} dt + C_1$$

$$= -\frac{mx}{T^m} \int t^{m-1}\left(1 + \alpha t^\beta\right) dt + C_1$$

$$mx \left[t^m \quad \alpha t^{m+\beta} \right]$$

[Assuming a very small value of α $(0 \le \alpha < 1)$, the approximate solution is obtained by neglecting the second and higher order terms of α]

Now $I(T) = 0$

$$\Rightarrow C_1 = \frac{mx}{T^m}\left[\frac{T^m}{m} + \frac{\alpha T^{m+\beta}}{m+\beta}\right]$$

$$I(t) = \frac{mx}{T^m}\left[\frac{T^m}{m} + \frac{\alpha T^{m+\beta}}{m+\beta} - \left(\frac{t^m}{m} + \frac{\alpha t^{m+\beta}}{m+\beta}\right)\right] e^{-\alpha t^\beta} \qquad (2)$$

Order quantity, $Q = I(0) = x\left(1 + \frac{\alpha T^\beta m}{m+\beta}\right)$ (3)

The number of deteriorating units during one cycle,

$$D(T) = Q - \int_0^T D(t) dt$$

$$= Q - \int_0^T \frac{mx}{T^m} t^{m-1} dt$$

$$x\left(1 + \frac{\alpha T^\beta m}{m+\beta}\right) - x = \frac{m\alpha x T^\beta}{m+\beta} \qquad (4)$$

Using DCF approach, we have three cases on the trade credit terms.

Case I: Instantaneous cash-flows

In this case, we present the DCF approach to the inventory model of time-dependent deteriorating items under instantaneous inventory holding cost.

Hence at the beginning of each cycle, there will be cash out flows of ordering cost and purchasing cost. Since, the inventory carrying cost is proportional to the value of the inventory, the out-of-pocket inventory carrying cost per unit time at 't' is iCI(t). Hence, the present value of cash flow for the first order cycle $z_1(T)$ is

$$z_1(T) = H + CQ + iC\int_0^T I(t)e^{-Rt}dt$$

$$= H + Cx\left[1+\frac{m\alpha T^\beta}{m+\beta}\right] + iC\int_0^T \frac{mx}{T^m}\left[\frac{T^m}{m}+\frac{\alpha T^{m+\beta}}{m+\beta}-\frac{t^m}{m}-\frac{\alpha t^{m+\beta}}{m+\beta}\right]\left[1-\alpha t^\beta - Rt\right]dt$$

$$= H + Cx\left[1+\frac{m\alpha T^\beta}{m+\beta}\right] + \frac{iCmx}{T^m}\int_0^T\left[\frac{T^m}{m}+\frac{\alpha T^{m+\beta}}{m+\beta}-\frac{t^m}{m}-\frac{\alpha t^{m+\beta}}{m+\beta}-\frac{\alpha t^\beta T^m}{m}+\frac{\alpha t^{m+\beta}}{m}-\frac{RT^m t}{m}\right.$$

$$\left.-\frac{\alpha Rt T^{m+\beta}}{m+\beta}+\frac{Rt^{m+1}}{m}+\frac{\alpha Rt^{m+\beta+1}}{m+\beta}\right]dt$$

$$= H + Cx\left[1+\frac{m\alpha T^\beta}{m+\beta}\right] + iCmx\left[\frac{T}{m+1}+\frac{\alpha\beta T^{\beta+1}}{(\beta+1)(m+\beta+1)}-\frac{RT^2}{2(m+2)}-\frac{\alpha RT^{\beta+2}}{2(m+\beta+2)}\right] \quad (5)$$

Hence the present value of all future cash flows is

$$Z_1(T) = \sum_{n=0}^{\infty} z_1(T)e^{-nRT} = \frac{z_1(T)}{1-e^{-RT}}$$

Since $e^{-RT} \approx 1 - RT$ (approx.)

$\therefore\ 1-e^{-RT} \approx 1-(1-RT) = RT$

$\therefore$ Equation (5) becomes

i.e.

$$Z_1(T) = \frac{1}{RT}\left[H + Cx\left(1+\frac{m\alpha T^\beta}{m+\beta}\right) + iCmx\left\{\frac{T}{m+1}+\frac{\alpha\beta T^{\beta+1}}{(\beta+1)(m+\beta+1)}-\frac{RT^2}{2(m+2)}-\frac{\alpha RT^{\beta+2}}{2(m+\beta+2)}\right\}\right]$$

$$= \frac{1}{R}\left[\frac{H}{T} + Cx\left(\frac{1}{T}+\frac{m\alpha T^{\beta-1}}{m+\beta}\right) + iCmx\left\{\frac{1}{m+1}+\frac{\alpha\beta T^{\beta}}{(\beta+1)(m+\beta+1)}-\frac{RT}{2(m+2)}-\frac{\alpha RT^{\beta+1}}{2(m+\beta+2)}\right\}\right] \quad (6)$$

The optimal value of T can be found by solving $\frac{\partial Z_1(T)}{\partial T} = 0$

Diff. equation (6) partially w.r.t. 'T', and equating to zero, we get

$$\frac{\partial Z_1(T)}{\partial T} = \frac{1}{R}\left[\frac{-H}{T^2} + Cx\left(\frac{-1}{T^2}+\frac{m\alpha(\beta-1)T^{\beta-2}}{m+\beta}\right) + iCmx\left\{\frac{\alpha\beta^2 T^{\beta-1}}{(\beta+1)(m+\beta+1)}-\frac{R}{2(m+2)}-\frac{\alpha RT^{\beta}(\beta+1)}{2(m+\beta+2)}\right\}\right] = 0 \quad (7)$$

and

$$\frac{\partial^2 Z_1(T)}{\partial T^2} = \frac{1}{R}\left[\frac{2H}{T^3} + Cx\left(\frac{2}{T^3}+\frac{m\alpha(\beta-1)(\beta-2)T^{\beta-3}}{m+\beta}\right) + iCmx\left\{\frac{\alpha\beta^2(\beta-1)T^{\beta-2}}{(\beta+1)(m+\beta+1)}-\frac{\alpha R\beta(\beta+1)T^{\beta-1}}{2(m+\beta+2)}\right\}\right] > 0$$

Thus optimum value of T can be found from equation (7). Let it be 'T_1'. Then, the optimum value of order quantity

$Q_1 = x\left(1+\frac{\alpha T_1^\beta m}{m+\beta}\right)$ and minimum cost $Z_1(T_1)$ can be found from equation (6).

Case II: Credit only on the items in stock

In this case, payment is connected to the subsequent use of items. Here, there exist a credit period M. During this period, the customers make payment to the supplier immediately after the use of the items and the remaining balance is paid by the customer on the last day of the credit period. Here we have two cases depending on the value of 'T' and credit period 'M'.

Sub case I: If $T \le M$, then the present value of cash flows for the first cycle is

$$z_2(T) = H + C\int_0^T \frac{mx}{T^m}t^{m-1}e^{-Rt}dt + CD(T)e^{-RM} + iC\int_0^T I(t)e^{-Rt}dt$$

$$= H + C\frac{mx}{T^m}\int_0^T\left\{t^{m-1}(1-Rt)\right\}dt + C\frac{m\alpha xT^\beta}{m+\beta}e^{-RM} + iC\int_0^T\frac{mx}{T^m}\left[\frac{T^m}{m}+\frac{\alpha T^{m+\beta}}{m+\beta}-\frac{t^m}{m}-\frac{\alpha t^{m+\beta}}{m+\beta}\right]\left[1-\alpha t^\beta-Rt\right]dt$$

$$= H + Cx\left[1-\frac{RmT}{m+1}\right] + \frac{Cm\alpha xT^\beta}{m+\beta}e^{-RM} + iCmx\left\{\frac{T}{m+1}+\frac{\alpha\beta T^{\beta+1}}{(\beta+1)(m+\beta+1)}-\frac{RT^2}{2(m+2)}-\frac{\alpha RT^{\beta+2}}{2(m+\beta+2)}\right\}$$

The present value of all future cash flows is

$$Z_2(T) = \frac{z_2(T)}{1-e^{-RT}} = \frac{z_2(T)}{RT}$$

$$\therefore\ Z_2(T) = \frac{1}{R}\left[\frac{H}{T} + Cx\left(\frac{1}{T}-\frac{Rm}{m+1}\right) + \frac{Cm\alpha xT^{\beta-1}}{m+\beta}e^{-RM}\right.$$

$$\left.+iCmx\left\{\frac{1}{m+1}+\frac{\alpha\beta T^\beta}{(\beta+1)(m+\beta+1)}-\frac{RT}{2(m+2)}-\frac{\alpha RT^{\beta+1}}{2(m+\beta+2)}\right\}\right]$$

$$,\ T \le M \quad (8)$$

The necessary condition for $Z_2(T)$ to be minimum is $\frac{\partial Z_2(T)}{\partial T} = 0$

$$\frac{\partial Z_2(T)}{\partial T} = \frac{1}{R}\left[\frac{-H}{T^2} + Cx\left(\frac{-1}{T^2}\right) + \frac{Cm\alpha x(\beta-1)T^{\beta-2}}{m+\beta}e^{-RM}\right.$$

$$\left.+iCmx\left\{\frac{\alpha\beta^2T^{\beta-1}}{(\beta+1)(m+\beta+1)}-\frac{R}{2(m+2)}-\frac{\alpha R(\beta+1)T^\beta}{2(m+\beta+1)}\right\}\right] = 0$$

$$\frac{\partial^2 Z_2(T)}{\partial T^2}=\frac{1}{R}\left[\frac{2H}{T^3}+\frac{2Cx}{T^3}+\frac{Cm\alpha x(\beta-1)(\beta-2)T^{\beta-3}}{(m+\beta)e^{RM}}+iCmx\left\{\frac{\alpha\beta^2(\beta-1)T^{\beta-2}}{(\beta+1)(m+\beta+1)}-\frac{\alpha R\beta(\beta+1)T^{\beta-1}}{2(m+\beta+1)}\right\}\right]>0$$

Sub Case II: If T>M, then the present value of cash flows for the first cycle is

$$z_2(T)=H+C\int_0^M \frac{mx}{T^m}t^{m-1}e^{-Rt}dt+C\left(Q-\int_0^M \frac{mx}{T^m}t^{m-1}dt\right)e^{-RM}+iC\int_0^T I(t)e^{-Rt}dt$$

$$=H+C\frac{mx}{T^m}\left(\frac{M^m}{m}-\frac{RM^{m+1}}{m+1}\right)+C\left(x+\frac{m\alpha xT^{\beta}}{m+\beta}-\frac{xM^m}{T^m}\right)e^{-RM}+iCmx\left\{\frac{T}{m+1}+\frac{\alpha\beta T^{\beta+1}}{(\beta+1)(m+\beta+1)}-\frac{RT^2}{2(m+2)}-\frac{\alpha RT^{\beta+2}}{2(m+\beta+2)}\right\}$$

The present value of all future cash flows is

$$Z_2(T)=\frac{z_2(T)}{1-e^{-RT}}=\frac{z_2(T)}{RT}$$

$$\therefore\ Z_2(T)=\frac{1}{R}\left[\frac{H}{T}+\frac{Cmx}{T^{m+1}}\left(\frac{M^m}{m}-\frac{RM^{m+1}}{m+1}\right)+C\left(\frac{x}{T}+\frac{m\alpha xT^{\beta-1}}{(m+\beta)}-\frac{xM^m}{T^{m+1}}\right)e^{-RM}+iCmx\left\{\frac{1}{m+1}+\frac{\alpha\beta T^{\beta}}{(\beta+1)(m+\beta+1)}-\frac{RT}{2(m+2)}-\frac{\alpha RT^{\beta+1}}{2(m+\beta+2)}\right\}\right],\quad T>M \qquad (10)$$

The necessary condition for $Z_2(T)$ to be minimum is $\frac{\partial Z_2(T)}{\partial T}=0$

$$\Rightarrow \frac{1}{R}\left[\frac{-H}{T^2}-\frac{Cmx(m+1)}{T^{m+2}}\left(\frac{M^m}{m}-\frac{RM^{m+1}}{m+1}\right)+C\left(-\frac{x}{T^2}+\frac{m\alpha x(\beta-1)T^{\beta-2}}{(m+\beta)}+\frac{(m+1)xM^m}{T^{m+2}}\right)e^{-RM}+iCmx\left\{\frac{\alpha\beta^2T^{\beta-1}}{(\beta+1)(m+\beta+1)}-\frac{R}{2(m+2)}-\frac{\alpha R(\beta+1)T^{\beta}}{2(m+\beta+2)}\right\}\right]=0 \qquad (11)$$

$$\frac{\partial^2 Z_2(T)}{\partial T^2}=\frac{1}{R}\left[\frac{2H}{T^3}+\frac{Cm(m+1)(m+2)x}{T^{m+3}}\left(\frac{M^m}{m}-\frac{RM^{m+1}}{m+1}\right)+C\left(\frac{2x}{T^3}+\frac{m\alpha x(\beta-1)(\beta-2)T^{\beta-3}}{(m+\beta)}-\frac{(m+1)xM^m(m+2)}{T^{m+3}}\right)+iCmx\left\{\frac{\alpha\beta^2(\beta-1)T^{\beta-2}}{(\beta+1)(m+\beta+1)}-\frac{\alpha R\beta(\beta+1)T^{\beta-1}}{2(m+\beta+1)}\right\}\right]>0$$

and the optimum value of $T=T_2$ can be found from equation (9) and (11).

Hence if the payments to the supplier is done immediately after the use of materials and if the credit period (M) is longer than cycle length (T), then only out of pocket cost and the discounted cost of deterioration are relevant in finding the optimal cycle length. When $T\le M$, then there would be no opportunity cost in the expression of total cash flows because in this case, the firm finances the inventory investment with the trade credit offered by its supplier.

Case III: Fixed Credit Period : I n this case credit period is fixed and hence, the customer pays the full purchase amount on the last day of the credit period. The present value of cash-flows for one cycle, z_3 (T) is

$$z_3(T)=H+CQe^{-RM}+iC\int_0^T I(t)e^{-Rt}dt$$

$$=H+Cx\left[1+\frac{\alpha mT^{\beta}}{m+\beta}\right]e^{-RM}+iCmx\left\{\frac{T}{m+1}+\frac{\alpha\beta T^{\beta+1}}{(\beta+1)(m+\beta+1)}-\frac{RT^2}{2(m+2)}-\frac{\alpha RT^{\beta+2}}{2(m+\beta+2)}\right\}$$

The present value of all future cash-flows is

$$Z_3(T)=\frac{z_3(T)}{1-e^{-RT}}=\frac{z_3(T)}{RT}$$

$$\therefore\ Z_3(T)=\frac{1}{R}\left[\frac{H}{T}+Cx\left(\frac{1}{T}+\frac{\alpha mT^{\beta-1}}{m+\beta}\right)e^{-RM}+iCmx\left\{\frac{1}{m+1}+\frac{\alpha\beta T^{\beta}}{(\beta+1)(m+\beta+1)}-\frac{RT}{2(m+2)}-\frac{\alpha RT^{\beta+1}}{2(m+\beta+2)}\right\}\right] \qquad (12)$$

For optimum value of T,

$$\frac{\partial Z_3(T)}{\partial T}=0$$

$$\Rightarrow \frac{1}{R}\left[\frac{-H}{T^2}+Cx\left(\frac{-1}{T^2}+\frac{\alpha m(\beta-1)T^{\beta-2}}{m+\beta}\right)e^{-RM}+iCmx\left\{\frac{\alpha\beta^2T^{\beta-1}}{(\beta+1)(m+\beta+1)}-\frac{R}{2(m+2)}-\frac{\alpha R(\beta+1)T^{\beta}}{2(m+\beta+2)}\right\}\right]=0 \qquad (13)$$

$$\frac{\partial^2 Z_3(T)}{\partial T^2}=\frac{1}{R}\left[\frac{2H}{T^3}+Cx\left(\frac{2}{T^3}+\frac{\alpha m(\beta-1)(\beta-2)T^{\beta-3}}{m+\beta}\right)e^{-RM}+iCmx\left\{\frac{\alpha\beta^2(\beta-1)T^{\beta-2}}{(\beta+1)(m+\beta+1)}-\frac{\alpha R\beta(\beta+1)T^{\beta-1}}{2(m+\beta+2)}\right\}\right]>0$$

Hence the optimum value of $T=T_3$ can be obtained from equation (13) and the corresponding optimal order quantity is

$$Q=Q_3=x\left(1+\frac{\alpha T_3^{\beta}m}{m+\beta}\right).$$

The corresponding optimal present value of all future cash-flows $Z_3(T)=Z_3(T_3)$ is obtained from equation (12). Equation (13) contains trade credit, the correct opportunity cost and the cost of deterioration, which are the discounted cost of deterioration. This results that effective capital cost should be less than that of the instantaneous payments.

V. CONCLUSION

In this paper, we have considered power demand pattern with variable rate of deterioration under the effect of inflation. Since it is not possible to forecast exact demand in advance, so we have considered probabilistic version of demand. Here, the demand pattern is same as deterministic but it depends on the value of x which may vary from 0 to ∞. Discounted cash flow approach for deteriorating items in presence of trade credit period is used for three cases. The optimal value of all future cash flows is found for three cases : instantaneous cash-flows, credit only on units in stock, fixed credit period.

REFERENCES

[1] Aggarwal, R., Rajput, D. and Varshney, N. K. 2009. Integrated inventory system with the effect of inflation and credit period. International Journal of Applied Engineering Research, Vol .4, No. II, pp. 2234-2248.

[2] Aggarwal, S.P. and Jaggi, C.K. 1995. Ordering policies of deteriorating items under permissible delay in payments. Journal of the Operational Research Society, Vol. 46, pp.658 — 662.

[3] Chang, H.J. Dye, C.Y. 2001. An inventory model for deteriorating items with linear demand under condition of permissible delay in payments. Production planning and control, Vol.12, pp. 2 74-282.

[4] Chung, K.J. and Hwang, Y.F. 2003. The optional cycle time for EOQ inventory model under permissible delay in payments, International Journal of Production Economics, Vol. 84, pp. 307-318.

[5] Chung. K.J. and Hwang, Y.F., and Huang, C.K. 2002. The replenishment decision for EOQ inventory model under permissible delay in payments. Op search, Vol. 39. No.5 & 6, pp.327- 340.

[6] Covert, R.P. and Philip, G.C. 1973. An EOQ model for deteriorating items with Weibull distributions deterioration. AHE Trans. Vol.5, pp.323-332.

[7] Deb, M. and Chaudhuri, K.S. 1986. An EOQ Model for items with finite rate of production and variable rate of. deterioration: Opsearch, Vol.23, pp. 175-181.

[8] Heng, K.J., Lambban, J., Linn, R.J. 1991. An order level lot—size inventory model for deteriorating items with finite replenishment rate. Conputers and Industrial Engineering, Vol .20, pp. 187-197.

[9] Hou, K.L. and Lin, L.C. 2009. A cash flow oriented EOQ Model with deteriorating items under permissible delay in payments. Journal of Applied Sciences, Vol. 9, No.9, pp. 1791-1794.

[10] Huang, Y.F. 2003. Optimal Retailer's ordering policies in the EOQ model under trade credit financing. Journal of the Operational Research Society, Vol.54, pp. 1011-1015.

[11] Huang, Y.F. 2007. Economic order Quantity under conditionally permissible delay in payments. European Journal of operational Research Vol.176, pp. 911-924.

[12] Hung. Y.F.. and Chung, K.J. 2003. Optimal replenishment and payment policies in the EOQ model under cash discount and trade credit, Asia-Pacific Journal of operations Research, Vol.20.pp. 171- 190.

[13] Hwang, H. and Shinn, SW. 1997. Retailer's pricing and lot- sizing policy for exponentially deteriorating product under condition of permissible delay in payments. Computers and Operations Research Vol.24. pp. 539-547.

[14] Jaggi. C.K. and Aggarwal. S.P. 1994. Credit financing in economic ordering policies of deteriorating Items. International Journal of Production Economics, Vol.34. pp. 151-159.

[15] Jaggi, C.K., Goyal S.K., and Goel, S.K. 2008.Retailer's optimal replenishments decisions with credit-linked demand under permissible delay in payments. European Journal of Operational Research. Vol. 190. pp. 130—135.

[16] Lee, W.N. and Wu, J-W, 2002. An EOQ model for items with Weibull distributed deterioration, shortages and Power Demand Patterns, Information and Management Sciences, Vol. 13, Number 2, pp 19-34.

[17] Liao, H.C., Tsai, C.H. and Su, CT. 2000. An inventory model with deteriorating items under inflation when a delay in payments is permissible, International Journal of production Economic, Vol.63, pp. 207-214.

[18] Misra, R.B. 1979. A study of inflation effects on inventory system. Logistic spectrum. Vol.9. pp. 260- 268.

[19] Roy Choudhary, M. and Chaudhuri, KS. (1983). An order level inventory model for deteriorating items with finite rate of replenishment. Opsearch, Vol.20, pp. 99 —106.

[20] Shah N.H. 1993. Probabilistic time scheduling model for an exponentially decaying inventory when delay in payments are permissible. International Journal of Production Economics, Vol.32. pp.77- 82.

[21] Teng, J.T., and Chang, C.T.2005. Economic production quantity models for deteriorating items with price and stock dependent demand, Computers and Operational Research, Vol.32, pp.297 — 308.

[22] Tripathi, R.P. and Misra, S.S.2010. Credit financing in economic ordering policies of non-deteriorating items with time-dependent demand rate. International Review of Business and Finance Vol.2, No.1, pp. 47-55.

[23] Tripathi, R.P. and Kumar, Manoj, 2011. International Journal of Business, Management and Social Sciences, Vol. 2, No. 3, 1, pp 75-84 credit financing in economic ordering policies of time-dependent deteriorating items.

[24] Wen-Chuan, 2002, Information and management sciences, an EOQ model for items with Weibull Distributed Deterioration, Shortages and Power Demand Pattern.

First Author – Neetu (Asst. Professor), PG Deptt. of Mathematics, APJ College of Fine Arts, Jalandhar.
Email : mannat_007ind@yahoo.co.in

Second Author – Sapna Mahajan (Asst. Professor), Deptt. of Mathematics, ARNI University, Kathgarh, H.P.,
Email : sapnamahajan1711@gmail.co

3.
4.

Third Author – Dr. Arun Kumar Tomer (Asst. Professor)
PG Deptt. of Mathematics, SMDRSD College, Pathankot.
Email : tomer14@rediffmail.com