Quest Journals
Journal of Research in Applied Mathematics
Volume 8 ~ Issue 2 (2022) pp: 18-24
ISSN(Online) : 2394-0743 ISSN (Print): 2394-0735
www.questjournals.org

Research Paper

Effect of Inflation on A Deteriorating Inventory Model With Non-Linear Holding Cost And Demand

*Sandeep Kumar[1], R.K. Sharma[1]
[1]*Department of Mathematics, S.G. (P.G.) College, Meerut, India*

Abstract
Deterioration become a major problem in any inventory modeling. Inflation is a concept that is strongly linked to the passage of time. Inflation is a state of dis-equilibrium in which a rise in the price level is caused by, or is the result of, an increase in purchasing power. So, we investigate the impact of inflation on an inventory model with non linear holding cost and nonlinear demand, as well as partial backlog shortages and trade credit, in this research. The software MATHEMATICA 12.0 is used to create numerical illustrations. We can see from the numerical representation that we make the most money when the overall trade credit duration is longer than the total cycle length. Sensitivity analysis is used to demonstrate how different parameters affect total profit. The profit will be higher when the deterioration rate is lower, according to the sensitivity analysis.
Keywords: Nonlinear holding cost, nonlinear demand, inflation, Deterioration, Trade credit.

R**eceived 09 Feb, 2022; **R**evised 20 Feb, 2022; **A**ccepted 23 Feb, 2022 © The author(s) 2022. **P**ublished with open access at **www.questjournals.org

1. INTRODUCTION & LITERATURE REVIEW

Damage, spoilage, decay, and other factors that reduce the usability of a commodity are all examples of degradation. Deterioration has been extensively researched in recent years due to its significant impact on an inventory system's overall profitability. Ghare and Scharder introduce the concept of degradation (1963).

Inflation become a realistic situation in today's business scenario. Inflation is defined as an increase in the overall level of prices of goods and services in an economy overtime, resulting in a loss of money's purchasing power. Many businesses have seen their purchasing power eroded as a result of excessive inflation. As a result, the impact of inflation on inventory models can not be neglected. Buzacott (1975) was the first to use the rate of inflation in inventory modelling with various pricing regimes. Bierman and Thomas (1977) presented an inventory decision policy that took inflation into account. Vrat and Padmanabhan (1990) considered an inflationary environment when developing a model with a stock-dependent consumption rate. Hariga (1994) gave an economic analysis of dynamic inventory models with the effect of inflation. Using a discounted cash flow method, Jaggi et al. (2007) developed an optimal replacement policy for degrading items in an inflationary context. Jaggi and Verma (2010) investigated a two-warehouse system with a linear demand trend in an inflationary environment for degrading products. With total backlog, shortages are permissible in this paradigm.

*Sandeep Kumar (Email ID- *sandeepmaths87@gmail.com)*

Tayal et al. (2014) created a degrading model with effective preservation technology investment in an inflationary context. Rao and Rao (2015) investigated an EOQ model that allowed for payment delays for degrading items in an inflationary setting, however shortages were not allowed in this model.

For getting idea to make this study, we review the given papers as: H.J. Weiss (1982) developed an EOQ inventory model based on the assumption that inventory holding costs are a convex function of time. After that, (Goh, M., 1994) relaxed the assumption that the holding cost is constant in the (Baker, R.C., Urban, T.L., 1988) inventory model. Following that, (Giri, B.C., Chaudhuri, K.S., 1988) generalised (Goh, M., 1994) inventory model and created an inventory model with deteriorating items. (Gupta, R., and Vrat, P., 1986) developed a multi-item inventory model that took into account stock-dependent consumption rates. Following that, Baker, R.C. and Urban, T.L. (1988) developed an EOQ inventory model for a stock-dependent demand with power-form. Following that, (Mandal, B.N., Phaujdar, S., 1989) established an economic production

inventory model for degrading products based on a constant production rate and stock-dependent demand. (Datta, T.K. Pal, A.K., 1990) proposed an inventory model in which demand is a function of inventory level a year later. The Baker and Urban (1988) inventory model for deteriorating products was later revisited and extended by S. Pal et al. (1993). V. Pando et al. (2013) investigated a stock-dependent demand inventory model for degrading products. They used holding cost as a function of time in their inventory model. G. Dabson et al. (2017) recently presented an EOQ inventory model for perishable objects, in which demand for items/products is based on their age. L.A. San-Jose et al. (2018) created an EOQ inventory model for a single commodity whose demand is affected by both time and price. In their inventory model, they also factored in the possibility of shortages. Li.R. Teng (2018) developed an inventory model for perishable commodities, in which demand is determined by the selling and reference price, the product's freshness, and the available supply.
The recent literature review for this study is shown in tabular form in table 1.

Table 1. Literature Review

Author's name	Demand	Holding cost	Deterioration	Inflation	Trade credit	Shortages
(Ghare, P.M. and Schrader, 1963)	Constant	Constant	✓	×	×	×
(Yang, C.T., 2014)	Stock dependent demand	Stock dependent	✓	×	×	×
(Agarwal, Rani and Singh, 2015)	Time dependent	Linear	✓	✓	×	Partially backlogged
(Rastogi. Mohit and ; Singh.S.R, 2018)	Selling price dependent	constant	✓	✓	×	Partially backlogged
(Cárdenas-barrón *et al.*, 2018)	Non -linear stock dependent	Nonlinear stock dependent	×	×	✓	Partially backlogged
Present study	Non- linear Stock dependent	Nonlinear stock dependent	Constant	✓	✓	Partially backlogged

This research looks at a nonlinear stock dependent demand and nonlinear holding cost, constant deterioration inventory model. This inventory model was created from the perspective of the retailer, in which the supplier grants the merchant a trade credit period. We change the typical assumption of a zero-ending inventory level to a non-zero-ending inventory level in this case (the ending inventory level can be positive, zero or negative). When the ending inventory level is negative, shortages are allowed and partially backlogged at a constant backlog rate 'δ'. In this research, we build an inventory model with shortages for decaying items that is affected by shortages. The basic goal of both inventory models is to find the best ordering strategy.

II. ASSUMPTIONS AND NOTATIONS:

2.1 Assumptions:

1. The inventory system's planning horizon is infinite.
2. The rate of replenishment in instantaneous, and the lead time is minimal.
3. Shortages are allowed, and they are partially backlogged at a rate of 'δ', δ>0.
4. A single-level trade credit policy is taken into account. In this case, the supplier/manufacturer/retailer extends credit to his or her consumer for a set length of time, with well defined terms and conditions.
5. $H(t) = h[I(t)]^{\gamma}$; $\gamma > 0$.gives the holding cost, which is a nonlinear function that is dependent on stock level.
6. The demand function is considered as a nonlinear stock dependent demand given by

$$D(t) = \begin{Bmatrix} a[I(t)]^{\beta} & I(t) \geq 0 \\ a & I(t) \leq 0 \end{Bmatrix}$$

7. Inflation is considered in this model with rate of inflation 'r'; r > 0.
8. Rate of deterioration is to be considered as constant with parameter 'θ'; θ> 0.

2.2 Notations:

C_o = replenishment cost per order.
c = purchasing cost per unit.
p = selling price per unit.
h= unit time holding cost per unit per unit time.
c_s = unit time shortage cost per unit per unit time.
c_l = lost sale cost per unit.

γ = the elasticity of holding cost; $0 < \gamma < 1$.
β = demand elasticity; $0 < \beta < 1$.
δ = partial backlogging parameter; a fraction of the demand within the stock out period that is backlogged, δ € [0,1].
a = Scale parameter of the demand rate.
q(t) = units inventory level at any time *t* where $0 \le t \le T$.
M = unit time the retailer's trade credit period provided by the supplier.
r = Rate of inflation; $0 < r < 1$.
θ = Constant rate of deterioration; $0 < \theta < 1$.
I_e = unit time Interest earned by the retailer.
I_p = unit time Interest paid by the retailer.
Q = order quantity per cycle.
B = the end inventory level at time 'T'.
λ = time at which inventory level is zero.
τ = the length of replenishment cycle.
T = Punit time the total profit per unit time.

III. MATHEMATICAL FORMULATION:

This study is developed for any retailing firm. The inventory model states that at the start of the cycle, 'Q' units of products are in stock. When the inventory level on hand reaches 'B' units, a replenishment must be performed, and the order quantity must be (Q-B), bringing the inventory level to 'Q' units at the start of the next cycle. The supplier also provides the store with a trade credit period (M). For inventory models with scarcity (B≤0), Calculate the total profit per unit time. The inventory level is defined by the governing differential equation shown below.

$$\frac{dI_1(t)}{dt} = -D(t) - \theta I_1(t)$$

$$\frac{dI_1(t)}{dt} = -a[I_1(t)]^{\beta} - \theta I_1(t)(0 \le t \le \lambda) \qquad (\mathbf{1})$$

$$\frac{dI_2(t)}{dt} = -D\delta$$

$$\frac{dI_2(t)}{dt} = -a\delta(\boldsymbol{\lambda} \le \boldsymbol{t} \le \boldsymbol{\tau}) \qquad (\mathbf{2})$$

with,

$$I_1(0) = Q$$

$$I_2(\lambda) = 0 = I_1(\lambda)$$

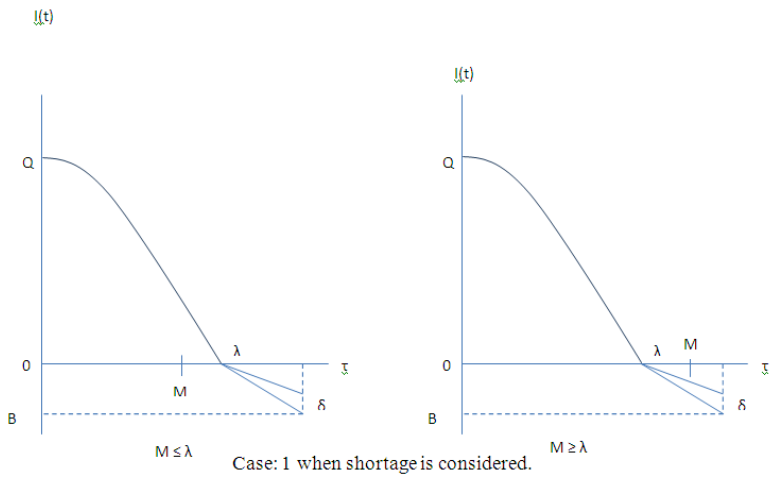
On solving equation (1), (2). We get,

$$I_1(t) = [\frac{a}{\theta}(e^{\theta(1-\beta)(\lambda-t)} - 1)]^{\frac{1}{(1-\beta)}}$$

$$I_2(t) = B + a\,\delta\,(\tau - t)$$

$$Q = [\frac{a}{\theta}(e^{\theta(1-\beta)\lambda} - 1)]^{\frac{1}{(1-\beta)}}$$

$$B = a\delta(\lambda - \tau)$$



Case: 1 when shortage is considered.

IV. INVENTORY COST COMPONENTS:

4.1 Holding Cost:

$$= h\int_0^{\lambda}[I_1(t)]^{\gamma}e^{-rt}dt$$

$$= hQ^{1-\beta}[\frac{(1-e^{-r\lambda})}{r}+\gamma(\theta+\frac{a}{Q^{1-\beta}})(\frac{r\lambda e^{-r\lambda}+e^{-r\lambda}-1`}{r^2}]$$

4.2 Ordering cost: C_0

4.3 Purchasing cost:

= c(Q-B)

$$= c[(\frac{a}{\theta}(e^{\theta(1-\beta)\lambda}-1)^{\frac{1}{(1-\beta)}}-B]$$

4.4 Sales Revenue cost:

= p(Q-B)

$$= p[(\frac{a}{\theta}(e^{\theta(1-\beta)\lambda}-1)^{\frac{1}{(1-\beta)}}-B]$$

4.5 Deteriorating cost:

$$= d\int_0^{\lambda}\theta I_1(t)dt$$

$$= d\theta[[a(1-\beta)]^{\frac{1}{(1-\beta)}}[\frac{1-e^{-r\lambda}}{r}+\frac{[e^{-r\lambda}+r\lambda e^{-r\lambda}-1]}{r^2\lambda(1-\beta)}]$$

4.6 Shortage cost:

$$= -c_s\int_{\lambda}^{\tau}I_2(t)e^{-rt}dt$$

$$= -c_s[\frac{B}{r}(e^{-r\lambda}-e^{-r\tau})+\frac{\delta a}{r^2}(e^{-r\tau}+r(\tau-\lambda)e^{-r\lambda}-e^{-r\lambda})$$

4.7 Opportunity cost:

$$= c_l\int_{\lambda}^{\tau}a(1-\delta)e^{-rt}dt$$

$$= \frac{c_l a(1-\delta)(e^{-r\lambda}-e^{-r\tau})}{r}$$

4.8 Trade credit policy:

There are two scenarios in which a payment delay is acceptable. In the first scenario, the trade credit period is shortage than the time it takes for inventory to be completed. In the second scenario, the trade credit period is longer than the time it takes for inventory to be completed.

4.8(a) For case: 1(M ≤ λ)

(1) Interest pay:

$$= ci_p\int_M^{\tau}I(t)e^{-rt}dt$$

$$= ci_p(a(1-\beta)^{\frac{1}{1-\beta}}[\left(\frac{(e^{-rM}-e^{-r\tau})}{r}\right)+\frac{(1-rM)e^{-rM}-(1-r\tau)e^{-r\tau}}{r^2\lambda(1-\beta)}]$$

(2) Interest earn:

$$= pi_e\int_0^{M}a[I_1(t)]dt$$

$$= \frac{pi_e a^{1+\frac{\beta}{1-\beta}}(1+\beta)^{\frac{\beta}{1-\beta}}}{\frac{\beta}{1-\beta}+1}(\frac{\lambda^{\frac{\beta}{1-\beta}+2}-(\lambda-M)^{\frac{\beta}{1-\beta}+2}}{\frac{\beta}{1-\beta}+2}-\frac{(\lambda-M)^{\frac{\beta}{1-\beta}+1}M}{\frac{\beta}{1-\beta}+1}$$

4.8(b) For case: 2 (M ≥ λ)

(1) Interest pay = 0

(2) Interest earn :

$$= pi_e(\int_0^{\lambda}D(t)tdt+(M-\tau)\int_0^{\lambda}D(t)dt$$

$$= pi_e(\frac{a^{1+\frac{\beta}{1+\beta}}(1+\beta)^{\frac{\beta}{1+\beta}}\lambda^{\frac{\beta}{1+\beta}+2}}{(\frac{\beta}{1+\beta}+1)(\frac{\beta}{1+\beta}+2)}+\frac{(M-\tau)a^{1+\beta}(1-\beta)^{\beta}\lambda^{\beta+1}}{\beta+1})$$

5(A) TOTAL PROFIT FOR CASE: 1

T.P₁ = (Sales-revenue-cost) + (interest-earn) – (ordering-cost) – (purchasing-cost) – (holding-cost) – (deteriorating-cost) – (shortage-cost) – (opportunity-cost) – (interest pay).

$$= p[(\frac{a}{\theta}(e^{\theta(1-\beta)\lambda}-1)^{\frac{1}{(1-\beta)}}-B]$$

$$+\frac{\boldsymbol{pi_e a^{1+\frac{\beta}{1-\beta}}(1+\beta)^{\frac{\beta}{1-\beta}}}}{\frac{\beta}{1-\beta}+1}(\frac{\lambda^{\frac{\beta}{1-\beta}+2}-(\lambda-M)^{\frac{\beta}{1-\beta}+2}}{\frac{\beta}{1-\beta}+2}-\frac{(\lambda-M)^{\frac{\beta}{1-\beta}+1}M}{\frac{\beta}{1-\beta}+1_0}-c[(\frac{a}{\theta}(e^{\theta(1-\beta)\lambda}-1)^{\frac{1}{(1-\beta)}}-B]-h[a(1-\beta)^{\frac{\gamma}{(1-\beta)}}\frac{\lambda^{(\frac{\gamma}{(1-\beta)}+1)}}{(\frac{\gamma}{(1-\beta)}+1)}(1-\frac{r\lambda}{(\frac{\gamma}{(1-\beta)}+2)})]$$

$$-d\theta[(\lambda a(1-\beta))^{\frac{1}{(1-\beta)}}[\frac{(1-e^{-r\lambda})}{r}+\frac{[e^{-r\lambda}+r\lambda e^{-r\lambda}-1]}{\lambda(1-\beta)r^2}]+c_s[\frac{B}{r}(e^{-r\lambda}-e^{-r\tau})+\frac{\delta a}{r^2}(e^{-r\tau}+r(\tau-\lambda)e^{-r\lambda}-e^{-r\lambda})-\frac{c_l a(1-\delta)(e^{-r\lambda}-e^{-r\tau})}{r}-ci_p(a(1-\beta))^{\frac{1}{1-\beta}}(\frac{(1-rM)e^{-rM}}{r}-\frac{(1-r\tau)e^{-r\tau}}{\lambda(1-\beta)r^2})$$

5(b)TOTAL COST FOR CASE: 2

T.P₂ = (Sales-revenue-cost) + (interest-earn) – (ordering-cost) – (purchasing-cost) – (holding-cost) – (deteriorating-cost) – (shortage-cost) – (opportunity-cost).

$$= s[(\frac{a}{\theta}(e^{\theta(1-\beta)\lambda}-1)^{\frac{1}{(1-\beta)}}-B]$$

$$+ci_e(\frac{a^{1+\frac{\beta}{1+\beta}}(1+\beta)^{\frac{\beta}{1+\beta}}\lambda^{\frac{\beta}{1+\beta}+2}}{(\frac{\beta}{1+\beta}+1)(\frac{\beta}{1+\beta}+2)}+\frac{(M-\tau)a^{1+\beta}(1-\beta)^{\beta}\lambda^{\beta+1}}{\beta+1})-C_0$$

$$-c[(\frac{a}{\theta}(e^{\theta(1-\beta)\lambda}-1)^{\frac{1}{(1-\beta)}}-B]-h[a(1-\beta)^{\frac{\gamma}{(1-\beta)}}\frac{\lambda^{(\frac{\gamma}{(1-\beta)}+1)}}{(\frac{\gamma}{(1-\beta)}+1)}(1-\frac{r\lambda}{(\frac{\gamma}{(1-\beta)}+2)})]$$

$$-d\theta[a(1-\beta)^{\frac{\gamma}{(1-\beta)}}\frac{\lambda^{(\frac{\gamma}{(1-\beta)}+1)}}{(\frac{\gamma}{(1-\beta)}+1)}(1-\frac{r\lambda}{(\frac{\gamma}{(1-\beta)}+2)})]+c_s[\frac{B}{r}(e^{-r\lambda}-e^{-r\tau})+\frac{\delta a}{r^2}(e^{-r\tau}+r(\tau-\lambda)e^{-r\lambda}-e^{-r\lambda})-\frac{c_l a(1-\delta)(e^{-r\lambda}-e^{-r\tau})}{r}$$

V. TOTAL AVERAGE COST

Total average cost for both cases are given as follows:

$$A.P_1=\frac{T.P_1}{T}$$

$$A.P_2=\frac{T.P_2}{T}$$

5.1 Numerical Illustration

Example 1**.** Let us consider a situation in which shortages is considers and input parameters are in appropriate units as a=100, h=5, d=3, r=0.06, c=40, p=50, $\gamma = 0.1$, $\beta = 0.04$,$C_0 = 50$, $\delta = 0.02$,$C_s = 0.4$,$i_p = 0.3$,$\theta = 0.05$,$i_e = 0.35$, $C_i = 0.05$, $\tau = 90$

For case 1 when Trade credit period $M \leq \lambda$

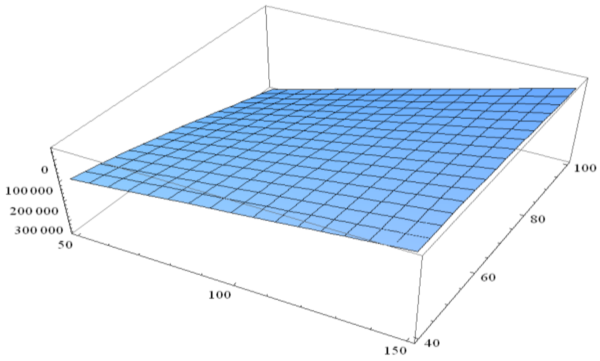
We get TP₁= 176.695, $\lambda = 7.74897$, M =5.86919

For case 2 when trade credit period $M \geq \lambda$

We get TP₁= 150228, $\lambda = 74.721$, M =74.721

From numerical illustration we conclude that we get maximum profit in case 2.

Concavity



5.2 Sensitivity Analysis

Table 2 : Sensitivity of different parameters are as shown below.

Parameters	%Value	M	λ	TP_2
a	+20%	75.141	75.141	183280
	+10%	74.940	74.940	166684
	0%	74.721	74.940	150228
	-10%	74.4796	74.4796	133923
	-20%	74.2109	74.2109	117786
h	+20%	69.9721	69.9721	139770
	+10%	72.1922	72.1922	144688
	0%	74.721	74.721	150228
	-10%	79.6606	77.6606	156576
	-20%	81.1742	81.1742	164023
β	+20%	80.5603	80.5603	178238
	+10%	77.5503	77.5503	163323
	0%	74.721	74.721	150228
	-10%	72.0659	72.0659	138671
	-20%	69.577	69.577	128422
δ	+20%	74.7202	74.7201	150229
	+10%	74.7206	74.7206	150228
	0%	74.721	74.721	150228
	-10%	74.7214	74.7214	150227
	-20%	74.7219	74.7219	150226
r	+20%	77.15	77.15	155322
	+10%	79.4971	79.4971	160243
	0%	74.721	74.721	150228
	-10%	79.497	79.497	160243
	-20%	69.541	69.541	139480
θ	+20%	64.0412	64.0412	132266
	+10%	68.955	68.955	140641
	0%	74.7219	74.7219	150226
	-10%	81.5733	81.5733	161279
	-20%	89.8278	89.8278	174117

5.3 Observations

1. On increases in the demand parameter ‘a’ the total profit increases and cycle length and trade credit period also increases.
2. On increases in the holding cost parameter ‘h’ the total profit decreases and cycle length and trade credit period also decreases.
3. On increases in the demand elasticity $'\beta'$ the total profit increase and also cycle length and trade credit period increases.
4. On increases in the backlogging rate $'\delta'$ the total profit increases and cycle length and trade credit period decreases.
5. On increases in the inflation rate ‘r’ the total profit is increases or decreases and cycle length and trade credit period is also increases or decreases.
6. On increase in the deterioration rate the total profit decreases and cycle length and trade credit period is also decreases.

VI. CONCLUSION

When a retailer receives a trade credit period from his/her supplier. This paper investigates the retailer's optimal approach based on non linear holding and stock dependent demand of his goods. Basically, this study looks at how products deteriorate under the influence of inflation when shortages are allowed an partially backlogged. The major goal of this research is to find the best ordering quantity and finishing inventory level for maximising the retailer's total profit per unit of time. From the numerical illustration we find that when the trade credit period exceeds the cycle length, we make the most money. From sensitivity analysis we found that the lower the rate of inventory deterioration, the higher the overall profit.

REFERENCES

[1]. Agarwal, A., Rani S. & Singh, S. (2015) : Mathematical production inventory model for deteriorating items with time dependent demand rate under the effect of inflation and shortages. International Journal of computer & Mathematical Sciences, 4, pp.138-148.

[2]. Baker, R.C. & Urban, T.L., (1988) : A deterministic inventory system with inventory dependent demand rate. Journal of the Operational Research Society, 39(9), pp. 823–831.

[3]. Bierman, H.J. & Thomas, J. (1977) : Inventory decisions under inflationary conditions. Decision Sciences, 8(1), pp. 151–155.

[4]. Buzacott, J. A. (1975) : Economic order quantities with inflation. Operational Research Quarterly, 26(3), pp. 553–558.

[5]. Cardenas-barron, L. E., Shaikh, A.A., Tiwari, S. & Garza, G.T. (2018) : An EOQ inventory model with nonlinear stock dependent holding cost, nonlinear stock dependent demand and trade credit. Computers & Industrial Engineering. doi: 0.1016/j.cie.2018.12.004

[6]. Datta, T.K. & Pal, A.K. (1990) : A note on an inventory model with inventory-level dependent demand rate. Journal of the Operational Research Society, 41(10), pp. 971–975.

[7]. Dobson, G., Pinker, E. J. & Yildiz, O. (2017) : An EOQ model for perishable goods with age-dependent demand rate. European Journal of Operational Research, 257(1), pp. 84–88.

[8]. Ghare, P.M. & Schrader, G. F. (1963) :A Model for an exponential decaying inventory. Journal of Industrial Engineering, 14, pp. 238–243.

[9]. Giri, B.C. & Chaudhuri, K.S. (1998) : Deterministic models for perishable inventory with stock-dependent demand rate and nonlinear holding cost. European Journal of Operational Research, 105(3), pp. 467–474.

[10]. Goh, M., (1994) : EOQ models with general demand and holding cost functions. European Journal of Operational Research, 73(1), pp. 50–54.

[11]. Gupta, R. & Vrat, P. (1986) : Inventory model with multi-items under constraint systems for stock dependent consumption rate. Operations Research, 24(1), pp. 41–42.

[12]. Hariga, M. A. (1994) : Economic analysis of dynamic inventory models with non-stationary costs and demand. International Journal of Production Economics, 36(3), pp. 255–266.

[13]. Jaggi, C.K., Aggarwal, K.K. & Goel, S. K. (2007) : Optimal order policy for deteriorating items with inflation induced demand. International Journal of Production Economics, 103(2), pp. 707–714.

[14]. Jaggi, C.K. & Verma, P. (2010) : Two-warehouse inventory model for deteriorating items with linear trend in demand and shortages under inflationary conditions. International Journal of Procurement Management, 3(1), pp. 54–71.

[15]. Li, R. & Teng, J.T. (2018) : Pricing and lot-sizing decisions for perishable goods when demand depends on selling price, reference price, product freshness and displayed stocks. European Journal of Operational Research, 270(3), pp. 1099–1108.

[16]. Mandal, B.N. & Phaujdar, S. (1989) : An inventory model for deteriorating items and stock-dependent consumption rate. Journal of the Operational Research Society, 40(5), pp. 483–488.

[17]. Pal, S., Goswami, A. & Chaudhuri, K.S. (1993) : A deterministic inventory model for deteriorating items with stock-dependent demand rate. International Journal of Production Economics, 32(3), pp. 291–299.

[18]. Pando, V., San-Jose, L.A., Garcia-Laguna, J. & Sicilia, J. (2013) : An economic lot-size model with non-linear holding cost hinging on time and quantity. Journal of Production Economics, 145(1), pp. 294–303.

[19]. Rao, K.S. & Rao, S. E. (2015) : Inventory model under permissible delay in payments and inflation with generalised Pareto lifetime. International Journal of Procurement Management, 8(1–2), pp. 202–226.

[20]. Rastogi. M. & Singh, S.R. (2018) : A production inventory model for deteriorating products with selling price dependent consumption rate and shortages under inflationary environment. International Journal of Procurement management, Vol. 11, No.1, pp. 36-52.

[21]. San-Jose, L. A., Sicilia, J. & Alcaide-Lopez-de-Pablo, D. (2018) : An inventory system with demand dependent on both time and price assuming backlogged shortages. European Journal of Operational Research, 270(3), pp. 889–897.

[22]. Tayal, S., Singh, S.R., Sharma, R. & Chauhan, A. (2014) : Two echelon supply chain model for deteriorating items witheffective investment in preservation technology. International Journal of Mathematics in Operational Research, 6(1), pp. 84–105.

[23]. Vrat, P. & Padmanabhan, G. (1990) : An inventory model under inflation for stock dependent consumption rate items. Engineering Costs and Production Economics, 13(1–3), pp. 379–383.

[24]. Weiss, H.J. (1982) : Economic order quantity models with nonlinear holding costs. European Journal of Operational Research, 9(1), pp. 95–108.

[25]. Yang, C.T. (2014) : An inventory model with both stock-dependent demand rate and stock-dependent holding cost rate. International Journal of Production Economics, (155), pp. 24–221.