Price Dependent Quadratic Demand Inventory Models with Variable Holding Cost and Inflation Rate

ISBN: 978-81-924713-8-9

R. Venkateswarlu
Gitam University
(rangavajhala_v@yahoo.co.in)
M. S. Reddy
BVSR Engineering College
(naveenasrinu@gmail.com)

An attempt is made to develop an inventory model for perishable items when the demand rate is a quadratic function of price and the rate of deterioration is a linear function of time. It is also assumed that the holding cost is a linear function of time. Under instantaneous replenishment with zero lead-time, EOQ is determined for optimizing the total profit under inflation rate. The sensitive analysis is presented with numerical example at the end.

1. Introduction

It is true that the unit price and other inventory related costs are dependent on time. However, most of the inventory models in the literature have considered unit price and inventory related costs to be independent of time and constant over the period under consideration. Buzacott [1] modified the classical EOQ model incorporating constant inflation rate under different pricing policies. Misra [2], Gupta et al [3], Vrat and Padmanabhan [4] are some of the authors who have studied inventory models with special reference to inflation rate.

It is well known that the demand rate of any product is always in dynamic state. This variation is due to time or price or even with instantaneous level of inventory. An economic lot size model for price dependent demand under quantity and freight discounts was developed by Burwell [5]. An inventory system of ameliorating items for price dependent demand rate was considered by Mondal et al [6]. You [7] developed an inventory model with price and time dependent demand. Ajanta Roy [8] has developed an inventory model for deteriorating items with price dependent demand and time varying holding cost.

Inventory modelers so far have considered two types of price dependent demand scenarios, linear and exponential. The linear price dependent demand implies a uniform change in the demand rate of the product per unit price whereas exponential price dependent demand implies a very high change in demand rate of the product per unit price. These two scenarios are quite unusual in realistic situations. Thus quadratic price dependent demand may be an alternative approach to the existing two scenarios. So, it is reasonable to assume that the demand rate, in certain commodities, due to seasonal variations may follow quadratic function of time [*i.e.,* $D(t) = a + bp + cp^2;\ a \geq 0,\ b \neq 0,\ c \neq 0$]. The functional form given above explains the accelerated growth/decline in the demand patterns which may arise due to seasonal demand rate (Khanra and Chaudhuri [9]). We may explain different types of realistic demand patterns depending on the signs of a and b. Bhandari and sharma [10] have studied a Single Period Inventory Problem with Quadratic Demand Distribution under the Influence of Marketing Policies. Khanra and Chaudhuri [9] have discussed an order-level inventory problem with the demand rate represented by a continuous quadratic function of time. Sana and Chaudhuri [11] have developed a stock-review inventory model for perishable items with uniform replenishment rate and stock-dependent demand. Kalam et al [12] have studied the problem of production lot-size inventory model for Weibull deteriorating item with quadratic demand, quadratic production and shortages. An order level EOQ model for deteriorating items in a single warehouse system with price depended demand in non-linear (quadratic) form has been studied by Patra et al [13]. Venkateswarlu and Mohan [14] studied inventory model for time varying deterioration and price dependent quadratic demand with salvage value. Venkateswarlu and Reddy [15] developed time dependent quadratic demand inventory model under inflation. Recently, Venkateswarlu and Reddy [16] studied inventory models when the demand is time dependent quadratic demand and the delay in payments is acceptable.
In this paper, we try to develop an integrated model which contains both the perishability and inflation phenomena with price dependent quadratic demand situation. The inventory deterioration is assumed to be constant. The solutions of the models are presented and also discussed the sensitivity of the models at the end.

2. Assumptions and Notations

The mathematical model is developed on the following assumptions and notations:

i) The Selling rate *D(p)* at time *t* is assumed to be $D(p) = a + bp + cp^2,\ a \geq 0, b \neq 0,\ c \neq 0.$ Where, '*a*' is the initial rate of demand '*b*' is the rate with which the demand rate increases and '*c*' is the rate with which the change in the rate demand rate itself increases.
ii) Replenishment rate is infinite and lead time is zero.
iii) p is the selling price per unit.

iv) The rate of inflation is constant

v) The unit cost and other inventory related cost are subjected to the same rate of inflation, say k. This implies that the ordering quantity can be determined by minimising the total system cost over the planning period.

vi) *A(t)* is the ordering cost at time *t*.

vii) $\theta(0 < \theta < 1)$ is the constant rate of deterioration.

viii) *C(t)* denotes unit cost at time *t*.

ix) *I (t)* is the inventory level at time *t*.

x) *Q(t)* is the ordering quantity at time *t=0*

xi) *'h'* is per unit holding cost excluding interest charges per unit per year.

3. Formulation and Solution of the Model

The objective of the model is to determine the optimum profit for items having price dependent quadratic demand and the rate of deterioration follows a linear function of time with no shortages.

The inventory level depletes as the time passes due to demand and deterioration during $(0,t_1)$ and due to demand only during the period (t_1, T).

If I(t) be the inventory level at time t, the differential equations which describes the inventory level at time t are given by

$$\frac{dI(t)}{dt} + \theta.t.I(t) = -(a + bp + cp^2), \qquad 0 \le t \le t_1 \qquad (1)$$

$$\frac{dI(t)}{dt} = -(a + bp + cp^2), \qquad t_1 \le t \le T \qquad (2)$$

Together with $I(t_1)=0$ and I(T)=0.

The solution of equations (1) and (2)

$$I(t)=(a+bp+cp^2)\left((t_1-t)-(t_1-t)\left(\frac{\theta t^2}{2}\right)+\left(\frac{\theta t_1^{\,3}}{6}-\frac{\theta t^3}{6}\right)\right) \qquad 0 \le t \le t_1$$

$$I(t) = (a + bp + cp^2)(t_1 - t) \qquad t_1 \le t \le T$$

Let us consider the Ordering Quantity is *Q*. If $t = T$ then $I(0) = Q$

$$Q = (a + bp + cp^2)\left(T + \frac{\theta T^3}{6}\right)$$

Let $C(t)$ denotes the unit cost at time t.

i.e., $C(t) = C_0 e^{kt}$ where C_0 is the unit cost at time zero.

Let $A(t)$ denotes the Ordering cost at time t.

i.e., $A(t) = A_0 e^{kt}$ where A_0 is the ordering cost at time zero.

Total system cost during the planning period 'τ' is the sum of the Material cost, ordering cost and Carrying cost. Assume that τ = m*T, Where 'm' is an integer for the number of replenishments to make during the period'τ', and 'T' is time between replenishments.

The Ordering cost during the period $(0, \tau)$ is

$$A(0) + A(T) + A(2T) + A(3T) + ...+ A(m-1)T]$$
$$= A_0 e^{(0)kT} + A_0 e^{(1)kT} + A_0 e^{(2)kT} + A_0 e^{(3)kT} + ...+ A_0 e^{(m-1)kT}]$$
$$= A_0 (1 + e^{kT} + e^{2kT} + e^{3kT} + ...+ e^{(m-1)kT})$$

The Ordering Cost is $= A_0\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)$ where $\tau = mT$.

The Material cost during the period $(0, \tau)$ is

$$Q[C(0)+C(T)+C(2T)+C(3T)+..................+C(m-1)T]$$
$$=Q[C_0e^{(0)kT}+C_0e^{(1)kT}+C_0e^{(2)kT}+C_0e^{(3)kT}+.........+C_0e^{(m-1)kT}]$$
$$=QC_0(1+e^{kT}+e^{2kT}+e^{3kT}+.........+e^{(m-1)kT})$$
$$=QC_0\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)$$

Similarly, The Carrying Cost/holding cost during the period $(0,\tau)$ is

$$C(t)\,h\int_0^T I(t)\,dt$$

But we have $C(t)=C_0\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)$ in the period $(0,\tau)$

The Carrying Cost/holding cost is

$$=C_0\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)h\int_0^T I(t)\,dt$$
$$=C_0\,h\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)\left(\int_0^{t_1} I(t)dt+\int_{t_1}^{T} I(t)dt\right)$$
$$=C_0\,h\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)\left[(a+bp+cp^2)\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}\right)-\left[\frac{(a+bp+cp^2)(T-t_1)^2}{2}\right]\right]$$

The total cost over the period $(0,\tau)$ is

= Ordering cost + Material cost + Carrying cost

$$=A_0\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)+QC_0\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)+C_0\,h\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)\left(\int_0^{t_1} I(t)dt+\int_{t_1}^{T} I(t)dt\right)$$
$$=\left(A_0+QC_0+C_0\,h\left(\int_0^{t_1} I(t)dt+\int_{t_1}^{T} I(t)dt\right)\right)\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)$$
$$=\left(\begin{array}{l}A_0+C_0(a+bp+cp^2)\left(T+\frac{\theta T^3}{6}\right)\\ +C_0h\left((a+bp+cp^2)\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}\right)-\frac{(a+bp+cp^2)(T-t_1)^2}{2}\right)\end{array}\right)\left(\frac{e^{k\tau}-1}{e^{kT}-1}\right)$$

If shortages are not allowed then the Sales revenue per cycle is given by

$$p\int_0^T D(p)dt=p\int_0^T(a+bp+cp^2)dt$$
$$=pT(a+bp+cp^2)$$

The total profit $f(p,T)$ per unit time = (1/T) (Sales revenue – Total cost)

$$f(p,T)=p(a+bp+cp^2)-\left(\begin{array}{l}A_0+C_0(a+bp+cp^2)\left(T+\frac{\theta T^3}{6}\right)\\ +C_0h\left(\begin{array}{l}(a+bp+cp^2)\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}\right)\\ -\frac{(a+bp+cp^2)(T-t_1)^2}{2}\end{array}\right)\end{array}\right)\left(\frac{e^{k\tau}-1}{T(e^{kT}-1)}\right)$$

The total profit is maximum if $\frac{\partial(f(p,T))}{\partial p}=0,\ \frac{\partial(f(p,T))}{\partial T}=0$

i.e.,

$$\frac{\partial(f(p,T))}{\partial p}=\left[\begin{array}{l}\left(a+2bp+3cp^{2}\right)-(b+2pc)C_0\left(T+\frac{\theta T^{3}}{6}\right)\left(\frac{e^{\tau k}-1}{T(e^{Tk}-1)}\right)\\-(b+2pc)C_0h\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}-\frac{(T-t_1)^2}{2}\right)\left(\frac{e^{\tau k}-1}{T(e^{Tk}-1)}\right)\end{array}\right]=0$$

and

$$\frac{\partial(f(p,T))}{\partial T}=\left[\begin{array}{l}A_0\left(\frac{e^{\tau k}-1}{T^{2}(e^{Tk}-1)}\right)+\left(a+bp+cp^{2}\right)C_0\left(T+\frac{\theta T^{3}}{6}\right)\left(\frac{e^{\tau k}-1}{T^{2}(e^{Tk}-1)}\right)\\+\left(a+bp+cp^{2}\right)C_0h\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}-\frac{(T-t_1)^2}{2}\right)\left(\frac{e^{\tau k}-1}{T^{2}(e^{Tk}-1)}\right)\\-\left(a+bp+cp^{2}\right)\left(C_0\left(1+\frac{\theta T^{2}}{2}\right)-C_0h(T-t_1)\right)\left(\frac{e^{\tau k}-1}{T(e^{Tk}-1)}\right)\\+A_0\left(\frac{ke^{Tk}(e^{\tau k}-1)}{T(e^{Tk}-1)^{2}}\right)+\left(a+bp+cp^{2}\right)C_0\left(T+\frac{\theta T^{3}}{6}\right)\left(\frac{ke^{Tk}(e^{\tau k}-1)}{T(e^{Tk}-1)^{2}}\right)\\+\left(a+bp+cp^{2}\right)C_0h\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}-\frac{(T-t_1)^2}{2}\right)\left(\frac{ke^{Tk}(e^{\tau k}-1)}{T(e^{Tk}-1)^{2}}\right)\end{array}\right]=0$$

The Optimal value of T is obtained solving equation f (p, T) by MATHCAD

$$\frac{\partial^{2}(f(p,T))}{\partial p^{2}}=\left[\begin{array}{l}\left(2b+6cp\right)-(2c)C_0\left(T+\frac{\theta T^{3}}{6}\right)\left(\frac{e^{\tau k}-1}{T(e^{Tk}-1)}\right)\\-(2c)C_0h\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}-\frac{(T-t_1)^2}{2}\right)\left(\frac{e^{\tau k}-1}{T(e^{Tk}-1)}\right)\end{array}\right]$$

$$\frac{\partial^{2}(f(p,T))}{\partial T^{2}}=\left[\begin{array}{l}A_0\left(\frac{e^{\tau k}-1}{T^{3}(e^{Tk}-1)}\right)-A_0\left(\frac{ke^{Tk}(e^{\tau k}-1)}{T^{2}(e^{Tk}-1)^{2}}\right)\\+\left(a+bp+cp^{2}\right)C_0\left(1+\frac{\theta T^{2}}{2}\right)\left(\frac{e^{\tau k}-1}{T^{2}(e^{Tk}-1)}\right)\\-\left(a+bp+cp^{2}\right)2C_0\left(T+\frac{\theta T^{3}}{6}\right)\left(\frac{e^{\tau k}-1}{T^{3}(e^{Tk}-1)}\right)\\-\left(a+bp+cp^{2}\right)C_0\left(T+\frac{\theta T^{3}}{6}\right)\left(\frac{ke^{Tk}(e^{\tau k}-1)}{T^{2}(e^{Tk}-1)^{2}}\right)\\+\left(a+bp+cp^{2}\right)2C_0h\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}-\frac{(T-t_1)^2}{2}\right)\left(\frac{e^{\tau k}-1}{T^{3}(e^{Tk}-1)}\right)\\-\left(a+bp+cp^{2}\right)C_0h(T-t_1)\left(\frac{e^{\tau k}-1}{T^{2}(e^{Tk}-1)}\right)\\-\left(a+bp+cp^{2}\right)C_0h\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}-\frac{(T-t_1)^2}{2}\right)\left(\frac{ke^{Tk}(e^{\tau k}-1)}{T(e^{Tk}-1)^{2}}\right)\end{array}\right]$$

$$\frac{\partial^{2}(f(p,T))}{\partial p\,\partial T}=\left[\begin{array}{l}\left(b+2cp\right)C_0\left(T+\frac{\theta T^{3}}{6}+h\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}-\frac{(T-t_1)^2}{2}\right)\right)\left(\frac{e^{\tau k}-1}{T^{2}(e^{Tk}-1)}\right)\\-\left(b+2cp\right)C_0\left(1+\frac{\theta T^{2}}{2}-h(T-t_1)\right)\left(\frac{(e^{\tau k}-1)}{T(e^{Tk}-1)}\right)\\+\left(b+2cp\right)C_0\left(T+\frac{\theta T^{3}}{6}+h\left(\frac{t_1^2}{2}+\frac{\theta t_1^4}{12}-\frac{(T-t_1)^2}{2}\right)\right)\left(\frac{ke^{Tk}(e^{\tau k}-1)}{T(e^{Tk}-1)^{2}}\right)\end{array}\right]$$

Also satisfying the following condition

$$\frac{\partial^2(f(p,T))}{\partial p^2} < 0, \qquad \frac{\partial^2(f(p,T))}{\partial T^2} < 0,$$

And

$$\left(\frac{\partial^2(f(p,T))}{\partial p^2}\right)\left(\frac{\partial^2(f(p,T))}{\partial T^2}\right) - \left(\frac{\partial^2(f(p,T))}{\partial p \partial T}\right)^2 > 0$$

It is found that the optimality conditions are satisfied for the following two cases viz.,
(i) $b < 0$ and $c > 0$ which gives retarded growth in demand model
(ii) $b < 0$ and $c < 0$ gives accelerated decline in demand model

3.1 Numerical Example

To demonstrate the effectiveness of the models developed, a numerical example is taken with the following values for the parameters.

a =150, b = 5, c =0.01, A_0 = 250,
C_0=4, θ =0.1, i = 0.05, k = 0.04

The MATHCAD output is presented in Table-1 and Table-2 which contains the optimum values of time (*T*), ordering quantity (*Q*) and total profit *f(p,T)* of the system for various values of inflation parameter (*k*) and deterioration parameter (*θ*). These tables provide certain important insights about the problem under study. Some observations are as follows:

The behaviour of both the models developed here is almost similar in nature but the rate of change is slightly different. The optimal values of cycle time, ordering quantity and total cost increases with an increase in the inflation rate parameter '*k*'. For some particular values of *θ*, when the inflation rate *k* increases from 0.05 to 0.10, the cycle time and ordering quantity increases while the total profit *f(p,T)* also increases in both the models.

For some particular values of *k*, when *θ* increases from 0.05 to 0.10, the cycle time and ordering quantity decreases whereas total profit *f(p,T)* increases in both the models.

3.2 Sensitive Analysis

We now study sensitivity of the models developed to examine the implications of underestimating and overestimating the parameters individually and all together on optimal value of cycle time, ordering quantity and total system profit. The results are shown in Table-3 and Table-4. The following observations are made from these two tables:

(i) The ordering quantity *(Q)*, the unit price (*p*) and the total system profit *f(p,T)* increases (decreases) with the increase (decrease) in the value of the parameter '*a*' where as the cycle time *(T)* is inversely related with the parameter '*a*'.
(ii) Increase (decrease) in the values of the parameters '*b*' *and* '*c*' decrease (increase) the price per unit, ordering quantity and the total profit *f(p,T)* while the cycle time increases (decreases) with 'b' and decreases (increases) with 'c'. However the rate of increase/decrease is marginal in case 'p' and 'T'.

The ordering quantity *(Q)*, the unit price (*p*), and the total system profit *f(p,T)* increases (decreases) with the decrease (increase) in the value of the parameters 'θ' and 'C_0'.

(iii) The optimum value of the total profit, ordering cost and cycle time is marginal but the unit price remain constant to the changes in the parameters A_0
(iv) The total profit of the system is more sensitive than the cycle time and ordering quantity when the values of all parameters are under-estimated or over-estimated by 15%.

Table 1 *Retarded Growth Model (I.E., A>0, B<0 and C>0)*

S.No	*a*	*b*	*c*	*k*	*p*	*T*	*f(p, T)*	*Q*
1	150	-5	0.01	0.05	15.787	9.158	1008	2050
2	150	-5	0.01	0.06	15.785	9.295	1009	2117
3	150	-5	0.01	0.07	15.784	9.445	1009	2192
4	150	-5	0.01	0.08	15.782	9.612	1010	2279
5	150	-5	0.01	0.09	15.780	9.801	1011	2380
6	150	-5	0.01	0.10	15.778	10.017	1011	2499

Table 2 *Retarded Decline Model (I.E., A>0, B<0 and C<0)*

S.No	*a*	*b*	*c*	*k*	*p*	*T*	*f(p, T)*	*Q*
1	150	-5	-0.01	0.05	14.421	9.136	978.360	1980
2	150	-5	-0.01	0.06	14.419	9.271	978.956	2044
3	150	-5	-0.01	0.07	14.417	9.421	979.550	2129
4	150	-5	-0.01	0.08	14.416	9.587	980.141	2200
5	150	-5	-0.01	0.09	14.414	9.774	980.730	2297
6	150	-5	-0.01	0.1	14.412	9.988	981.316	2411

Table 3 *Retarded Growth Model (A>0, B<0 And C>0)*

Parameters	% change	Change in *p* (%)	Change in *T* (%)	Change in *f (pct.)* (%)	Change in *Q* (%)
a	-15%	-15.6078	1.375846	-24.6693	-21.8049
	-5%	-5.23215	0.414938	-8.21538	-7.21951
	5%	5.263825	-0.38218	8.234127	7.121951
	15%	15.87382	-1.04826	24.70238	21.31707
b	-15%	20.05448	0.054597	9.52381	9.414634
	-5%	5.846583	0.010919	3.174603	3.121951
	5%	-5.20682	-0.01092	-3.16954	-3.12195
	15%	-14.0812	-0.03276	-9.53165	-9.41463
c	-15%	-0.76645	-0.02184	-0.19841	-0.29268
	-5%	-0.25971	-0.01092	-0.09921	-0.09756
	5%	0.266042	0.010919	0.099206	0.097561
	15%	0.798125	0.021839	0.198413	0.243902
C_0	-15%	-0.03801	1.397685	0.793651	3.073171
	-5%	-0.01267	0.414938	0.297619	0.878049
	5%	0.012669	-0.38218	-0.19841	-0.82927
	15%	0.04434	-1.05918	-0.69444	-2.29268
θ	-15%	-0.08868	6.693601	0.099206	4.682927
	-5%	-0.03167	2.096528	0	1.512195
	5%	0.031672	-1.98733	0	-1.5122
	15%	0.088681	-5.6235	-0.09921	-4.29268
A_0	-15%	0	-1.23389	0.396825	-2.63415
	-5%	0	-0.40402	0.099206	-0.87805
	5%	0	0.404018	-0.09921	0.878049
	15%	0	1.190216	-0.29762	2.585366
All	-15%	-0.12035	8.113125	-14.2977	-8.43902
	-5%	-0.03801	2.522385	-4.72877	-2.68293
	5%	0.04434	-2.36951	4.761905	2.536585
	15%	-15.6078	1.375846	14.0873	7.414634

Table 4 *Retarded Decline Model (A>0, B<0 and C<0)*

Parameters	% change	Change in *p* (%)	Change in *T* (%)	Change in *f (pct.)* (%)	Change in (%)
a	-15%	-4.79856	0.415937	-25.4286	-22.5253
	-5%	4.777755	-0.3831	-8.47623	-7.42424
	5%	14.27779	-1.06173	8.446789	7.373737
	15%	15.85188	-0.04378	25.41396	22.0202
b	-15%	4.798558	-0.01095	9.877755	9.494949

	-5%	-4.39637	0.010946	3.233983	361.3636
	5%	-12.1489	0.021891	-3.27742	-3.18182
	15%	0.603287	0.010946	-9.83237	-9.54545
c	-15%	0.194161	0	0.228137	0.252525
	-5%	-0.2011	-0.01095	0.076046	0.10101
	5%	-0.58942	-0.02189	-0.07605	-0.10101
	15%	-0.04161	1.368214	-0.22814	-0.25253
C_0	-15%	-0.01387	0.404991	0.75463	3.030303
	-5%	0.013869	-0.3831	0.251543	0.909091
	5%	0.041606	-1.03984	-0.25154	-0.80808
	15%	-0.09708	6.698774	-0.75463	-2.22222
θ	-15%	-0.03467	2.101576	0.071242	4.69697
	-5%	0.027737	-1.98117	0.023713	1.565657
	5%	0.090146	-5.63704	-0.02371	-1.46465
	15%	0	-1.20403	-0.07114	-4.29293
A_0	-15%	0	-0.39405	0.368167	-2.57576
	-5%	0	0.394046	0.122756	-0.80808
	5%	0	1.160245	-0.12265	0.858586
	15%	-0.12482	8.099825	-0.36806	2.575758
All	-15%	-0.04854	2.517513	-14.3071	-8.43434
	-5%	0.041606	-2.36427	-4.73956	-2.67677
	5%	0.145621	-6.65499	4.66495	2.575758
	15%	-4.79856	0.415937	14.06844	7.474747

4. References

1. Buzacott, J.A., 1975. Economic order quantities with inflation. Operat. Res.Q., Vol.26, pp553-558.
2. Misra, R.B., 1979. A note on optimal inventory management under inflation, Naval Res. Logist., Vol.26, pp.161-165.
3. Gupta, R., Vrat, P. and Swarup, K. (1985), "Inventory management development – A review with special reference to perishability, inflation and stock-dependent consumption", Towards continuing Education, Vol. 6, Oct. – Nov., pp.232-237.
4. Padmanabhan, G. and Vrat, P. 1990. An EOQ model for items with stock dependent consumption rate and exponential decay. Engineering Costs and Production Economics, 18(3), pp.241-246.
5. Burwell T.H., Dave D.S., Fitzpatrick K.E., Roy M.R., (1997) Economic lot size model for price-dependent demand under quantity and freight discounts, International Journal of Production Economics, 48(2), pp 141- 155.
6. Mondal, B., Bhunia, A.K., Maiti, M., (2003) An inventory system of ameliorating items for price dependent demand rate, Computers and Industrial Engineering, 45(3), pp 443-456.
7. You, S.P. (2005) Inventory policy for products with price and time dependent demands, Journal of the operations research society, 56, pp 870- 873.
8. Ajanta Roy, (2008), An inventory model for deteriorating items with price dependent demand and time-varying holding cost, AMO-Advance modeling and optimization, Vol.10, No.1.
9. R.M.Bhandari and P.K.Sharma.(2000) A single period inventory problem with quadratic demand distribution under the influence of Market policies', Eng. Science Vol. 12. No.2, pp. 117-127.
10. S.Kharna and K.S.Chaudhuri.(2003) 'A note on order-level inventory model for a deteriorating item with time-dependent quadratic demand' Computers and Operations research, Vol.30, pp.1901-1916.
11. Shibshankar Sana and K.S.Chaudhary.(2004) A Stock-Review EOQ Model with Stock-Dependent Demand, Quadratic Deterioration Rate', Advanced Modelling And Optimization, vol.6, No.2, pp 25-32.
12. A. Kalam, D. Samal, S. K. Sahu & M. Mishra (2010) A Production Lot-size Inventory Model for Weibull Deteriorating Item with Quadratic Demand, Quadratic Production and Shortages, International Journal of Computer Science & Communication, Vol. 1, No. 1, Jan. 2010, pp. 259-262.
13. Patra, S.K. Lenka, T.K. and Ratha, P.C. (2010), An Order Level EOQ Model for Deteriorating Items in a Single Warehouse System with Price Depended Demand in Non-Linear (Quadratic) Form, International Journal of Computational and Applied Mathematics, Vol.5 No.3, pp. 277–288
14. R.Venkateswarlu and R. Mohan (2013) An Inventory Model for Time Varying Deterioration and Price Dependent Quadratic Demand with Salvage Value, Journal of Computational and Applied Mathematics, 07/2013; 1(1):21-27.

15. R.Venkateswarlu and M.S.Reddy (2014a) Time Dependent Quadratic Demand Inventory Models Under Inflation, Global Journal of Pure and Applied Mathematics, Volume 10, Number 1 (2014), pp. 77-85.
16. R.Venkateswarlu and M.S.Reddy (2014b) Time Dependent Quadratic Demand Inventory Models when Delay in Payments is Acceptable, International Journal of Modern Engineering Research (IJMER), Vol. 4, No.3, pp 60-71.