Statistics in the Twenty-First Century: Special Volume
In Honour of Distinguished Professor Dr. Mir Masoom Ali
On the Occasion of his 75th Birthday Anniversary
PJSOR, Vol. 8, No. 3, pages 583-592, July 2012

An Inventory Model for Deteriorating Items with Permissible Delay in Payment and Inflation Under Price Dependent Demand

Manisha Pal
Department of Statistics
University of Calcutta, India
manishapal2@gmail.com

Hare Krishna Maity
Department of Statistics
University of Calcutta, India
hkmaity@gmail.com

Abstract

The paper studies an inventory model for deteriorating items when demand for the item is dependent on the selling price. Shortages are allowed and backlogged, and price inflation is taken into consideration. Further, it is assumed that the supplier permits the inventory manager to settle his accounts within a given specified time period. Numerical examples are cited to illustrate the model and to study the sensitivity of the model to change in model parameters.

Keywords and phrases: Inventory; Delay in payment; Deteriorating items; Backlogging of shortage; Selling price dependent demand; Inflation.

1. Introduction

In classical inventory models it is generally assumed that the inventory manager settles his account with the supplier as soon as the ordered quantity arrives. However, in today's business transactions it is frequently observed that the supplier allows his customer a grace period within which he can repay his dues without having to pay any interest, or may delay the payment beyond the permitted time in which case interest is charged. Since, before settling the account with the supplier, the inventory manager can sell the goods, accumulate revenue and earn interest, it makes economic sense for the manager to delay the settlement of his account to the last day of the permissible settlement period. Goyal (1985) first developed an EOQ model under the condition of permissible delay in payments. Shinn *et al.* (1996) extended the model by considering quantity discount for freight cost. Aggarwal and Jaggi (1995) and Hwang and Shinn (1997) extended Goyal's model to consider deterministic inventory model with constant rate of deterioration. Later Jamal *et al.* (1997) extended Aggarwal and Jaggi's model to allow for shortages. Pal and Ghosh (2006, 2007) studied deterministic inventory models with quantity dependent permissible delay period. Shah and Shah (1998) developed probabilistic inventory model for deteriorating items when delay in payment is permitted. Ghosh (2008) investigated a stochastic inventory model with stock dependent demand under conditions of permissible delay in payments.

The above models were developed under the assumption that inflation does not play a significant role on the inventory policy. However, from financial point of view, one may consider an inventory to be a capital investment, and, as such, it should compete with other assets for an organization's limited capital fund. It is, therefore, important to investigate how time-value of money influences various inventory policies. The first study in this direction has been reported by Buzacott (1975), who considered EOQ model with inflation, subject to different types of pricing policies. Misra (1979) developed a discounted-cost model and included internal (company) and external (general economy) inflation rates for various costs associated with an inventory system. Sarker and Pan (1994) surveyed the effects of inflation and the time value of money on order quantity with finite replenishment rate. Some studies were also conducted with variable demand, see, for example, Uthayakumar and Geetha (2009), Maity (2010), Vrat and Padmanabhan (1990), Datta and Pal (1991), Hariga (1995), Hariga and Ben-Daya (1996) and Chung (2003).

In this paper, we consider a dynamic inventory model for deteriorating items allowing shortages and under inflation, when demand is price dependent and the inventory manager enjoys a fixed permissible delay in payment. The paper is organized as follows. In section 2, we analyze the model. In section 3, examples are cited and a sensitivity analysis of the model is carried out. Finally, in section 4, a discussion on the model is given.

2. The Mathematical Model and Its Analysis

The following notations have been used in the study:

H : The finite planning horizon

r : The constant inflation rate, $0 < r < 1$

$p(t)$: The selling price at time t, $p(0) = p$

$R(t)$: The price dependent demand rate at time t

θ : The constant deterioration rate

M : The permissible delay in payment

I_r : The interest charged per unit of money per annum by the supplier

I_e : The interest earned per unit of money per annum

T : Length of a replenishment cycle

T_1 : Time to exhaust stock within a replenishment cycle, $0 \le T_1 < T$

A : The ordering cost per order at time $t = 0$

c : Purchase cost per unit at time $t = 0$

I : Fraction of the purchase cost per unit defining the holding cost per unit per annum

s : shortage cost per unit per annum at time $t = 0$

The demand rate at time t is given by

$$R(t) = a - bpe^{rt}, \quad t \le \frac{1}{r}\log\left(\frac{a}{bp}\right)$$

$$= 0, \text{ for } t > \frac{1}{r}\log\left(\frac{a}{bp}\right),$$

where $a, b \ge 0$. .

We take the length H of the planning horizon to be such that the demand rate at the end of the planning horizon remains non-negative, that is, $H \le \frac{1}{r}\log\left(\frac{a}{bp}\right)$. This may also be ensured by taking $a \succ\succ b$.

We assume that the planning horizon is divided into n reorder intervals of length T, so that we have $H = nT$. Further, the costs and selling price during a reorder cycle is assumed to remain the same as that at the beginning of the cycle. Thus, the price in the s^{th} cycle is given by $pe^{r(s-1)T}$, and hence the demand rate is

$$R(t) = a - bpe^{r(s-1)T}, (s-1)T \le t < sT, 1 \le s \le n.$$

The inventory policy is to place an order at the beginning of each reorder interval, and the order quantity is just sufficient to meet the backorders in the previous period and the demand during the first T_1 units of time in the current period.

Let, $I_s(t)$ denote the inventory level at time point t in the s^{th} cycle, $1 \le s \le n$. Since depletion of stock occurs owing to demand and deterioration, the following differential equations define transitions in inventory:

$$\frac{dI_s(t)}{dt} + \theta I_s(t) = -a + bpe^{r(s-1)T}, \ 0 \le t \le T_1 \ 1 \le s \le n$$

$$\frac{dI_{s-1}(t)}{dt} = -a + bpe^{r(s-1)T}, \ T_1 \le t \le T \ 1 \le s \le n$$

where $I_s(T_1) = 0, \quad \text{for } 1 \le s \le n.$

Solving the differential equations, we get

$$I_s(t) = \begin{cases} \frac{D_s}{\theta}\left(1 - e^{\theta(T_1 - t)}\right), & 0 \le t \le T_1, 1 \le s \le n \\ D_s(t - T_1), & T_1 \le t \le T, 1 \le s \le n, \end{cases}$$

where $D_s = -a + bpe^{r(s-1)T}$.

The different costs incurred during the planning horizon are as follows:

(i) Total ordering cost:

$$A_H(T, T_1) = A + Ae^{rT} + \cdots + Ae^{r(n-1)T}$$

$$= A\frac{e^{rH} - 1}{e^{rT} - 1}$$

(ii) Total purchasing cost:

$$C_H(T,T_1) = cI_0(0) + ce^{rT}\left(I_1(0) + \int_{T_1}^{T}(a-bp)\,dt\right) + \cdots + ce^{r(n-1)T}\left(I_{n-2}(0) + \int_{T_1}^{T}\left(a-bpe^{r(n-1)T}\right)dt\right)$$

$$= \frac{c}{\theta}\left(e^{\theta T_1}-1\right)\left(a\frac{e^{rH}-1}{e^{rT}-1} - bp\frac{e^{2rH}-1}{e^{2rT}-1}\right) + c(T-T_1)\left(a\frac{e^{rH-rT}-1}{e^{rT}-1} - bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)$$

(iii) Total holding cost:

$$K_H(T,T_1) = Ic\int_0^{T_1} I_0(t)dt + Ice^{rT}\int_0^{T_1} I_t(t)dt + \cdots + Ice^{r(n-1)T}\int_0^{T_1} I_{n-1}(t)dt$$

$$= \frac{Ic}{\theta^2}\left(e^{\theta T_1} - \theta T_1 - 1\right)\left(a\frac{e^{rH}-1}{e^{rT}-1} - bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)$$

(iv) Total deterioration cost:

$$D_H(T,T_1) = \theta c\int_0^{T_1} I_0(t)dt + \theta ce^{rT}\int_0^{T_1} I_t(t)dt + \cdots + \theta ce^{r(n-1)T}\int_0^{T_1} I_{n-1}(t)dt$$

$$= \frac{c}{\theta}\left(e^{\theta T_1} - \theta T_1 - 1\right)\left(a\frac{e^{rH}-1}{e^{rT}-1} - bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)$$

(v) Total shortage cost:

$$S_H(T,T_1) = -s\left(I_0(T) + e^{rT}I_1(T) + \cdots + e^{r(n-1)T}I_{n-1}(T)\right)$$

$$= s(T-T_1)\left(a\frac{e^{rH}-1}{e^{rT}-1} - bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)$$

(v) Total selling price:

$$P_H(T,T_1) = p\int_0^{T_1}(a-bp)dt + pe^{rT}\left(\int_0^{T_1}\left(a-bpe^{rT}\right)dt - I_0(T)\right)$$

$$+ \cdots + pe^{r(n-1)T}\left(\int_0^{T_1}\left(a-bpe^{r(n-1)T}\right)dt - I_{n-2}(T)\right)$$

$$= pT_1\left(a\frac{e^{rH}-1}{e^{rT}-1} - bp\frac{e^{2rH}-1}{e^{2rT}-1}\right) - pe^{rT}(T-T_1)\left(a\frac{e^{rH-rT}-1}{e^{rT}-1} - bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)$$

(vi) Total interest earned:

Since the inventory manager can earn revenue by selling his goods when $M \le T_1$, we have

$IE_H(T, T_1)$ = total interest earned during $(0, H)$

$$= pI_e\int_0^{T_1}(a-bp)(T_1-t)dt + pI_e e^{rT}\int_0^{T_1}\left(a-bpe^{rT}\right)(T_1-t)dt$$

$$+\ldots+pI_e e^{r(n-1)T}\int_0^{T_1}\left(a-bpe^{r(n-1)T}\right)(T_1-t)dt, \text{ when } M\le T_1$$

$$=0, \qquad \text{when } M\ge T_1$$

$$=pI_e\frac{T_1^{\,2}}{2}\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right), \text{ when } M\le T_1$$

$$=0, \qquad \text{when } M\ge T_1$$

(vii) Total interest payable:

$$IP_H(T,T_1)=cI_r\int_M^{T_1}I_0(t)dt+cI_re^{rT}\int_M^{T_1}I_1(t)dt+\cdots+cI_re^{(n-1)rT}\int_M^{T_1}I_{n-1}(t)dt$$

$$=\frac{cI_r}{\theta}\left(e^{\theta(T_1-M)}-\theta(T_1-M)-1\right)\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right), \text{when } M\le T_1$$

$$=cI_r\left(\int_0^{T_1}(a-bp)(T_1-t)dt+\int_{T_1}^{M}(a-bp)(M-t)dt\right)$$

$$+cI_re^{rT}\left(\int_0^{T_1}\left(a-bpe^{rT}\right)(T_1-t)dt+\int_{T_1}^{M}\left(a-bpe^{rT}\right)(M-t)dt\right)$$

$$+\ldots+cI_re^{r(n-1)T}\left(\int_0^{T_1}\left(a-bpe^{r(n-1)T}\right)(T_1-t)dt+\int_{T_1}^{M}\left(a-bpe^{r(n-1)T}\right)(M-t)dt\right)$$

$$=cI_r\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)\left(\frac{T_1^{\,2}}{2}+\frac{(M-T_1)^2}{2}\right), \text{when } M\ge T_1.$$

Hence, the total profit made in the interval [0, H] is:

$$C^M(T,T_1)=C_1^M(T,T_1), \text{ for } M\le T_1$$

$$=C_2^M(T,T_1), \text{ for } M\ge T_1,$$

where

$$C_1^M(T,T_1)=[pT_1+pI_e\frac{T_1^{\,2}}{2}-\left(e^{\theta T_1}-\theta T_1-1\right)\left(\frac{Ic}{\theta^2}+\frac{c}{\theta}\right)-\frac{cI_r}{\theta}\left(e^{\theta(T_1-M)}-\theta(T_1-M)-1\right)$$

$$-s(T-T_1)-\frac{c}{\theta}\left(e^{\theta T_1}-1\right)]\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)$$

$$-(T-T_1)\left(c+pe^{rT}\right)\left(a\frac{e^{rH-rT}-1}{e^{rT}-1}-bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)-A\frac{e^{rH}-1}{e^{rT}-1}$$

$$C_2^M(T,T_1)=[pT_1-cI_r\left(\frac{T_1^{\,2}}{2}+\frac{(M-T_1)^2}{2}\right)-\left(e^{\theta T_1}-\theta T_1-1\right)\left(\frac{Ic}{\theta^2}+\frac{c}{\theta}\right)$$

$$-\frac{cI_r}{\theta}\left(e^{\theta(T_1-M)}-\theta(T_1-M)-1\right)-s(T-T_1)-\frac{c}{\theta}\left(e^{\theta T_1}-1\right)\Big]\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)$$
$$-(T-T_1)\left(c+pe^{rT}\right)\left(a\frac{e^{rH-rT}-1}{e^{rT}-1}-bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)-A\frac{e^{rH}-1}{e^{rT}-1}$$

Lemma 1: Both $C_1^M(T,T_1)$ and $C_2^M(T,T_1)$ are decreasing function of *I* and *s*, for fixed T_1 and *T*.

Proof: We have,

$$\frac{\partial C_1^M(T_1,T)}{\partial I}=-\frac{c}{\theta^2}\left(e^{\theta T_1}-\theta T_1-1\right)\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)\le 0$$
$$\frac{\partial C_2^M(T_1,T)}{\partial I}=-\frac{c}{\theta^2}\left(e^{\theta T_1}-\theta T_1-1\right)\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)\le 0$$

and,

$$\frac{\partial C_1^M(T_1,T)}{\partial s}=-(T-T_1)\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)\le 0$$
$$\frac{\partial C_2^M(T_1,T)}{\partial s}=-(T-T_1)\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)\le 0$$

Thus, the total profit decreases with increase in the inventory holding cost and the shortage cost.

Lemma2: $C_1^M(T,T_1)$ and $C_2^M(T,T_1)$ are both concave in T_1, for given *T*.

Proof: We have

$$\frac{\partial^2 C_1^M(T_1,T)}{\partial T_1^2}=-\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)\frac{T^2}{H}\left(ce^{\theta T}\ (I+2)+cI_r e^{\theta(T_1-M)}-pI_e\right)\le 0,$$ since

$$\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)\ge 0 \text{ and } \left(ce^{\theta T}\ (I+2)+cI_r e^{\theta(T_1-M)}-pI_e\right)\ge 0.$$

Hence $C_1^M(T_1,T)$ is a concave function of T_1, for given *T*.

Similarly it can be shown that $C_2^M(T_1,T)$ is concave in T_1, for given *T*.

The optimal values of (T_1,T) are obtained so as to maximize $C^M(T_1,T)$.

It may be noted that the optimal values of (T_1,T) maximizing $C_1^M(T_1,T)$ satisfy $\frac{\partial C_1^M(T,T_1)}{\partial T_1}=0$ and $\frac{\partial C_1^M(T,T_1)}{\partial T}=0$, which reduce to the following equations:

$$c(2+I_r e^{-\theta M}+\frac{I}{\theta})e^{\theta T_1}-pI_eT_1-(cI_r+p+s)=\frac{(c+pe^{rT})\left(a\frac{e^{rH-rT}-1}{e^{rT}-1}-bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)}{\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)} \tag{2.1}$$

$$\begin{aligned}&(T-T_1)(c+pe^{rT})\left(a\frac{re^{rH-rT}(e^{rT}-1)+(e^{rH-rT}-1)re^{rT}}{(e^{rT}-1)^2}-2rbp\frac{e^{rH-rT}(e^{2rT}-1)+(e^{2rH-2rT}-1)e^{2rT}}{(e^{2rT}-1)^2}\right)\text{-}\\
&[pT_1+pI_e\frac{T_1^2}{2}-(e^{\theta T_1}-\theta T_1-1)\left(\frac{Ic}{\theta^2}+\frac{c}{\theta}\right)-\frac{cI_r}{\theta}\left(e^{\theta(T_1-M)}-\theta(T_1-M)-1\right)-s(T-T_1)\\
&-\frac{c}{\theta}(e^{\theta T_1}-1)]\left(a\frac{e^{rH}-1}{(e^{rT}-1)^2}re^{rT}-bp\frac{e^{2rH}-1}{(e^{2rT}-1)^2}2re^{2rT}\right)-(c+pe^{rT})\times\\
&\left(a\frac{e^{rH-rT}-1}{e^{rT}-1}-bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)\text{-}\ pre^{rT}(T-T_1)\left(a\frac{e^{rH-rT}-1}{e^{rT}-1}-bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)\\
&-A\frac{e^{rH}-1}{(e^{rT}-1)^2}re^{rT}]\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)^{-1}=s.\end{aligned} \tag{2.2}$$

Similarly, the optimal values of (T_1,T) maximizing $C_2^M(T_1,T)$ satisfy $\frac{\partial C_1^M(T,T_1)}{\partial T_1}=0$ and $\frac{\partial C_1^M(T,T_1)}{\partial T}=0$, which reduce to the following equations:

$$\begin{aligned}&p+s-c[I_r(M-1)-1-\frac{I}{\theta}]+cT_1(I+\theta)-ce^{\theta T_1}\left(2+\frac{I}{\theta}+I_re^{-\theta M}\right)\\
&=(c+pe^{rT})\frac{\left(a\frac{e^{rH-rT}-1}{e^{rT}-1}-bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)}{\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)}\end{aligned} \tag{2.3}$$

$$[\left(cI_r\left(\frac{T_1^2}{2}+\frac{(M-T_1)^2}{2}\right)+\left(e^{\theta T_1}-\theta T_1-1\right)\left(\frac{Ic}{\theta^2}+\frac{c}{\theta}\right)-pT_1+\frac{cI_r}{\theta}\left(e^{\theta(T_1-M)}-\theta(T_1-M)-1\right)\right.$$

$$\left.+s(T-T_1)+\frac{c}{\theta}\left(e^{\theta T_1}-1\right)\right)\left(a\frac{e^{rH}-1}{\left(e^{rT}-1\right)^2}re^{rT}-bp\frac{e^{2rH}-1}{\left(e^{2rT}-1\right)^2}2re^{2rT}\right)-\left(c+pe^{rT}\right)\times$$

$$\left(a\frac{e^{rH-rT}-1}{e^{rT}-1}-bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)-(T-T_1)\{pre^{rT}\left(a\frac{e^{rH-rT}-1}{e^{rT}-1}-bp\frac{e^{2rH-2rT}-1}{e^{2rT}-1}\right)$$

$$+\left(c+pe^{rT}\right)\left(a\frac{-re^{rH-rT}\left(e^{rT}-1\right)-\left(e^{rH-rT}-1\right)re^{rT}}{\left(e^{rT}-1\right)^2}-bp\frac{-2re^{rH-rT}\left(e^{2rT}-1\right)-\left(e^{2rH-2rT}-1\right)2re^{2rT}}{\left(e^{2rT}-1\right)^2}\right)\}$$

$$-A\frac{e^{rH}-1}{\left(e^{rT}-1\right)^2}re^{rT}]\left(a\frac{e^{rH}-1}{e^{rT}-1}-bp\frac{e^{2rH}-1}{e^{2rT}-1}\right)^{-1}=s\,. \qquad (2.4)$$

4. Numerical Examples

Example 1: Suppose A = Rs. 250, c=Rs. 20, p=Rs. 24, s =Re 0.1, I= 0.1, I_e=.12, I_r=.15, r=.02, θ=.02, M =0.1 year, H =4 years, a=2000, b= 0.1.

Using the software MATLAB, we get the following output:

For $M \le T_1$,

$T_{1\text{opt}}$= 0.226, T_{opt}= 0.433 and $\max C_1^M(T_1,T)=28879.11$

For $M \ge T_1$,

$T_{1\text{opt}}$ = 0.098, T_{opt}=0.443 and $\max C_2^M(T_1,T)=28060.3$.

Hence, the optimal solution is T_1= 0.226, T= 0.433, and $C^M(T_1,T)=28879.11$.

Example 2: Suppose A=250, c=Rs. 20, p=Rs. 25, s =Re 0.1, I= 0.1, I_e=.12, I_r=.15, r = 0.15, θ= 0.4, M =0.1 year, H =2 years, a=2000, b= 0.1.

MATLAB output is:

For $M \le T_1$, $T_{1\text{opt}}$= 0.01, T_{opt}= 0.395 and $\max C_1^M(T_1,T)=21067.82$;

For $M \ge T_1$, $T_{1\text{opt}}$= 0.002, T_{opt}= 0.393 and $\max C_2^M(T_1,T)=21073.55$.

Hence, the optimal solution is T_1= 0.002, T= 0.393, and $C^M(T_1,T)=21073.55$.

Example 3: The following tables show the change in the optimal values of T_1 and T with change in the model parameters H, M, r, p and θ. We take A= Rs. 250, c= Rs. 20, s= Re 0.1, I=0.1, I_e=0.12, I_r=.15, a=2000, b=0.1.

Table1: p= Rs.25, r=.02,θ=.02.

H	M=0.01			M=0.05			M=0.1			M=0.3			M=0.6		
	T_1	T	Profit	T_1	T	Profit	T_1	T	Profit	T_1	T	Profit	T_1	T	Profit
0.8	0.294	0.294	8413.3	0.298	0.298	8630.3	0.311	0.311	8857.7	0.423	0.423	9405.8	0.675	0.675	9730.6
1.0	0.294	0.294	8430.2	0.298	0.298	8647.6	0.311	0.311	8875.5	0.423	0.423	9424.7	0.675	0.675	9750.2
2.0	0.271	0.299	8522.5	0.298	0.298	8735.0	0.311	0.311	8965.2	0.423	0.423	9519.9	0.675	0.675	9848.7
4.0	0.165	0.394	9002.0	0.206	0.388	9100.9	0.256	0.379	9227.4	0.423	0.423	9714.2	0.675	0.675	10050
6.0	0.124	0.513	9460.2	0.165	0.505	9517.2	0.217	0.495	9590.8	0.420	0.434	9914.2	0.675	0.675	10256

Table2: p= Rs. 25, H=2, M = 0.01

r	θ=0.02			θ=0.08			θ=0.15			θ=0.2			θ=0.4		
	T_1	T	Profit	T_1	T	Profit	T_1	T	Profit	T_1	T	Profit	T_1	T	Profit
0.02	0.271	0.299	8522.5	0.132	0.265	8210.5	0.083	0.255	8090	0.065	0.251	8046	0.036	0.246	7968.8
0.05	0.217	0.309	8816.1	0.109	0.286	8615.9	0.069	0.278	8537.3	0.055	0.275	8508.5	0.030	0.271	8457.7
0.08	0.163	0.327	9201.4	0.084	0.312	9091.2	0.054	0.307	9047.4	0.043	0.305	9031.3	0.024	0.302	9002.8
0.10	0.125	0.344	9516.1	0.065	0.334	9452.7	0.042	0.330	9427.4	0.033	0.329	9418.1	0.018	0.326	9401.6
0.12	0.085	0.364	9882.4	0.045	0.357	9854.1	0.029	0.355	9842.7	0.023	0.354	9838.6	0.013	0.353	9831.1
0.15	0.019	0.396	10539	0.010	0.395	10538	0.010	0.395	10537	0.003	0.394	10537	0.002	0.393	10537
0.20	0.010	0.463	11850	0.004	0.460	11866	0.004	0.46	11866	0.004	0.460	11866	0.004	0.460	11866

Table 3: r=.02, H=4,θ =.02

M	P=22			P=24			P=26			P=28			P=30		
	T_1	T	Profit	T_1	T	Profit	T_1	T	Profit	T_1	T	Profit	T_1	T	Profit
0.01	0.077	0.721	3359.0	0.137	0.446	7058.1	0.194	0.361	10985	0.260	0.326	15051	0.322	0.322	19241
0.05	0.114	0.717	3381.5	0.177	0.441	7129.5	0.236	0.355	11114	0.305	0.319	15246	0.327	0.327	19468
0.10	0.161	0.713	3408.8	0.226	0.433	7219.8	0.287	0.345	11280	0.328	0.328	15483	0.341	0.341	19709
0.30	0.350	0.706	3506.0	0.416	0.416	7591.6	0.430	0.430	11837	0.446	0.446	16085	0.464	0.464	20336
0.50	0.539	0.716	3583.4	0.576	0.576	7831.7	0.596	0.596	12111	0.618	0.618	16393	0.642	0.642	20680

From the above tables we have the following observations:

(i) As M increases T_1 increases.

(ii) As H increases T_1 decreases.

(iii) As r increases T_1 decreases, but T increases.

(iv) As θincreases, both T_1 and T decrease.

(v) As p increases, both T_1 and T increase

Conclusion

The paper studies a dynamic inventory model for deteriorating items. The demand for the item is dependent on the selling price and unmet demand is backlogged. The replenishment source allows the inventory manager a certain fixed period of time to settle his accounts. No interest is charged during this period, but beyond it the manager has to pay an interest. The effect of inflation on various costs is also taken into consideration. The optimum ordering policy is determined by maximizing the total profit over the planning horizon.

References

1. Aggarwal, S.P. and Jaggi, C.K.: Ordering policies of deteriorating items under conditions of permissible delay in payments, *J. Operat. Res.Soc.*, 46, (1995) 658-662.
2. Chung, K.J.: An algorithm for an inventory model with inventory-level-dependent demand rate, *Comput. Operat. Res*. (2003), 30, 1311-1317.
3. Datta, T.K. and Pal, A.K.: Effects of inflation and time-value of money on an inventory model with linear time-dependent demand rate and shortages, *Eur. J. Operat. Res.* (1991), 52: 326-333.
4. Goyal, S.K.: Economic order quantity under conditions of permissible delay in payments, *J. Operat. Res.Soc.*, 36, (1985) 335-338.
5. Hariga, M.A.: Effects of inflation and time-value of money on an inventory model with time-dependent demand rate and shortages, *Eur. J. Operat. Res.* (1995), 81, 512-520.
6. Hariga, M. and Ben-Daya, M.: Optimal time-varying lot-sizing models under inflationary conditions. *Eur. J. Operat. Res.* (1996), 89, 313-325.
7. Hou, K.L. and Lin, L.C.: A cash flow oriented EOQ Model with deteriorating items under permissible delay in payments, *Journal of Applied Science* (2009), 9(9), 1791-1794.
8. Hwang, H. and Shinn, S.W.: Retailer's pricing and lot sizing policy for exponentially deteriorating product under condition of permissible delay in payments, *Computer & Operations Research*, 24, (1997) 539-547.
9. Jamal, A.M., Sarker, B.R. and Wang, S.: An ordering policy for deteriorating items with allowable shortage and permissible delay in payment, *J. Operat. Res.Soc.*, 48, (1997) 826-833.
10. Maity, A.K.: One machine multiple-product problem with production-inventory system under fuzzy inequality constraint. *Applied Soft Comput*. (2010), 10.1016/j.asoc. 2009. 12.029.
11. Pal, M. and Ghosh, S.K. (2006): An inventory model with shortage and quantity dependent permissible delay in payment, *Aust. Soc. Operat. Res. Bull.* (2006), 25(3).
12. Pal, M. and Ghosh, S.K. (2007): An inventory model for deteriorating items with quantity dependent permissible delay in payment and partial backlogging of shortage, *CSA Bulletin*, 59, September & December.
13. Shah, N.H. and Shah, Y.K.: A discrete-in-time probabilistic inventory model for deteriorating items under conditions of permissible delay in payments, *Inter. J. Syst. Sci.* (1998), 29, 121-126.
14. Shinn, S.W., Hwang, H.P. and Sung, S.: Joint price and lot size determination under conditions of permissible delay in payments and quantity discounts for freight cost, *Euro. J. Operat. Res.*, 91, (1996) 528-542.
15. Uthayakumar, R. and Geetha, K.V.: Replenishment policy for single item inventory model with money inflation, *OPSEARCH* (2009), 46(3), 345-357.
16. Vrat, P. and Padmanabhan, G.: An inventory model under inflation for stock-dependent consumption rate items, *Eng. Costs Prod. Econ.* (1990), 19, 379-383.