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Research Article

Joint Optimal Pricing and Inventory Control for Deteriorating Items under Inflation and Customer Returns

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This paper studies the effect of inflation and customer returns on joint pricing and inventory control for deteriorating items. We adopt a price and time dependent demand function, also the customer returns are considered as a function of both price and demand. Shortage is allowed and partially backlogged. The main objective is determining the optimal selling price, the optimal replenishment cycles, and the order quantity simultaneously such that the present value of total profit in a finite time horizon is maximized. An algorithm has been presented to find the optimal solution. Finally, we solve a numerical example to illustrate the solution procedure and the algorithm.

1. Introduction

Recently, many researchers have studied the problem of joint pricing and inventory control for deteriorating items. Generally, deterioration is defined as decay, damage, spoilage, evaporation, and loss of utility of the product. Most physical goods undergo decay or deterioration over time such as medicines, volatile liquids, blood banks, and others [1]. The first attempt to describe optimal ordering policies for deteriorating items was made by Ghare and Schrader [2]. Later, Covert and Philip [3] derived the model with variable deteriorating rate of two-parameter Weibull distribution. Goyal and Giri [4] presented a detailed review of deteriorating inventory literatures. Abad [5, 6] considered a pricing and lot-sizing problem for a perishable good under exponential decay and partial backlogging. Dye [7] proposed the joint pricing and ordering policies for a deteriorating inventory with price-dependent demand and partial backlogging. Dye et al. [8] developed an inventory and pricing strategy for deteriorating items with shortages when demand and deterioration rate are continuous and differentiable function of price and time, respectively. Chang et al. [9] introduced a deteriorating inventory model with price-time-dependent demand and partial backlogging. Nakhai and Maihami [10] developed the joint pricing and ordering policies for deteriorating items with partial backlogging where the demand is considered as a function of both price and time. Tsao and Sheen [11] proposed the problem of dynamic pricing and replenishment for a deteriorating item under the supplier's trade credit and the retailer's promotional effort. Sarkar [12] extended the model with finite replenishment rate, stock-dependent demand, imperfect production, and delay in payments with two progressive periods. Sarkar [13] proposed an EOQ (economic order quantity) model for finite replenishment rate with delay in payments. In this model, deterioration and demand of the item have been considered as a time-dependent function. Sett et al. [14] considered a two-warehouse inventory model with quadratic increasing demand and time-varying deterioration. This model is derived with a finite replenishment rate and unequal length of the cycle time. Sarkar et al. [15] developed an economic production quantity model with stochastic demand in an imperfect production system. This model is derived for both continuous and discrete random demands.

In all the above models, the inflation and the time value of money were disregarded, but most of the countries have suffered from large-scale inflation and sharp decline in the purchasing power of money during years. As a result, while determining the optimal inventory policies, the effects of inflation and time value of money cannot be ignored. First, Buzacott [16] presented the EOQ model with inflation.

Following Buzacott [16], several researchers (Misra [17], Jolai et al. [18], etc.) have extended their approaches to distinguish the inventory models by considering the time value of money, the different inflation rates for the internal and external costs, finite replenishment, shortages, and so forth. Park [19] derived the economic order quantity in terms of purchasing credit. Datta and Pal [20] discussed a model with shortages and time-dependent demand rates to study the effects of inflation and time value of money on a finite time horizon. Goel et al. [21] developed the model economic discount value for multiple items with restricted warehouse space and the number of orders under inflationary conditions. Hall [22] presented a new model with the increasing purchasing price over time. Sarker and Pan [23] surveyed the effects of inflation and the time value of money on the optimal ordering quantities and the maximum allowable shortage in a finite replenishment inventory system. Hariga and Ben-Daya [24] have presented time-varying lot-sizing models with a time-varying demand pattern, taking into account the effects of inflation and time value of money. Horowitz [25] discussed an EOQ model with a normal distribution for the inflation. Moon and Lee [26] developed an EOQ model under inflation and discounting with a random product life cycle. Mirzazadeh and Sarfaraz [27] presented a multiple-item inventory system with a budget constraint and the uniform distribution function for the external inflation rate. Dey et al. [28] developed the model for a deteriorating item with time-dependent demand rate and interval-valued lead time under inflationary conditions. Mirzazadeh et al. [29] considered stochastic inflationary conditions with variable probability density functions (pdfs) over the time horizon and the demand rate is dependent on the inflation rates. Wee and Law [30] developed a deteriorating inventory model taking into account the time value of money for a deterministic inventory system with price-dependent demand. Hsieh and Dye [31] presented pricing and inventory control model for deterioration items taking into account the time value of money. In their model, shortage was allowed and partially backlogged and the demand was assumed as a function of price and time. Sarkar and Moon [32] developed a production inventory model for stochastic demand with inflation in an imperfect production system. Sarkar et al. [33] presented an EMQ (economic manufacturing quantity) model for time varying demand with inflation in an imperfect production process. Sarkar et al. [34] considered an economic order quantity model for various types of deterministic demand patterns in which the delay periods and different discount rates on purchasing cost are offered by the supplier to the retailers in the presence of inflation.

In the classical EOQ models, customer returns have not been considered, while in supply chain retailers can return some or all unsold items at the end of the selling season to the manufacturer and receive a full or partial refund. Hess and Mayhew [35] studied the problem of customer return by using regression methods to model the returns for a large direct market. Anderson et al. [36] found that the quantity sold has a strong positive linear relationship with number of returns. Same as Hess and Mayhew, they used regression models to show that as the price increases, both the number of returns and the return rate increase. These empirical investigations provide evidence to support the view that customer returns increase with both the quantity sold and the price set for the product. Chen and Bell [37] considered the customer returns as a function of price and demand simultaneously. Pasternack [38] studied the newsvendor problem framework for a seasonal product where a percentage of the order quantity could be returned from the retailers to the manufacturer. Zhu [39] presented a single-item periodic-review model for the joint pricing and inventory replenishment problem with returns and expediting. Yet, only a few authors have investigated the effect of customer returns on joint pricing and inventory control.

In the previous research that considered the impact of customer returns on pricing and inventory control for deteriorating items, the effect of time value of money has not been considered. However, in order to consider the realistic circumstances, the effect of time value of money should be considered. On the other hand, in nearly all papers that consider the impact of customer returns on pricing and inventory control, the return functions are dependent on price or demand, separately. But the empirical findings of Anderson et al. [36] provide evidence to support the view that customer returns increase with both the quantity sold and the price set for the product. The present paper studies the effect of inflation and customer returns on the joint pricing and inventory control for deteriorating items. We assume that the customer returns increase with both the quantity sold and the product price. The demand is deterministic and depends on time and price simultaneously. Shortages are allowed and partially backlogged. An optimization procedure is presented to derive the optimal time with positive inventory, selling price, and the number of replenishments and then obtains the optimal order quantity when the total present value of profits is maximized. Thus, the replenishment and price policies are appropriately developed. Numerical examples are provided to illustrate the proposed model.

The rest of the paper is organized as follows. In Section 2, assumptions and notations throughout this paper are presented. In Section 3, we establish the mathematical model. Next, in Section 4, an algorithm is presented to find the optimal selling price and inventory control variables. In Section 5, we use a numerical example and, finally, summary and some suggestions for the future are presented in Section 6.

2. Notations and Assumptions

The following notations and assumptions are used throughout the paper.

Notations

A: Constant purchasing cost per order

c: Purchasing cost per unit

c_1: Holding cost per unit per unit time

c_2: Backorder cost per unit per unit time

c_3: Cost of lost sale per unit

p: Selling price per unit, where $p > c$

θ: Constant deterioration rate

r: Constant representing the difference between the discount (cost of capital) and the inflation rate

Q: Order quantity

T: Length of replenishment cycle time

t_1: Length of time in which there is no inventory shortage

SV: Salvage value per unit

H: Length of planning horizon

N: Number of replenishments during the time horizon H

T^*: Optimal length of the replenishment cycle time

Q^*: Optimal order quantity

t_1^*: Optimal length of time in which there is no inventory shortage

p^*: Optimal selling price per unit

$I_1(t)$: Inventory level at time $t \in [0, t_1]$

$I_2(t)$: Inventory level at time $t \in [t_1, T]$

I_0: Maximum inventory level

S: Maximum amount of demand backlogged

PWTP(p, t_1, T): The present-value of total profit over the time horizon.

Assumptions. In this paper, the following assumptions are considered.

(1) There is a constant fraction of the on-hand inventory deteriorates per unit of time and there is no repair or replacement of the deteriorated inventory.

(2) The replenishment rate is infinite and the lead time is zero.

(3) The demand rate, $D(p,t) = (a - bp)e^{\lambda t}$ (where $a > 0$, $b > 0$) is a linearly decreasing function of the price and decreases (increases) exponentially with time when $\lambda < 0$ ($\lambda > 0$) [11].

(4) Shortages are allowed. The unsatisfied demand is backlogged, and the fraction of shortage backordered is $\beta(x) = k_0\, e^{-\delta x}$, ($\delta > 0$, $0 < k_0 \le 1$), where x is the waiting time up to the next replenishment, δ is a positive constant, and $0 \le \beta(x) \le 1$, $\beta(0) = 1$ [5].

(5) The time horizon is finite.

(6) Following the empirical findings of Anderson et al. [36], we assume that customer returns increase with both the quantity sold and the price using the following general form: $R(p,t) = \alpha D(p,t) + \beta p$ ($\beta \ge 0$, $0 \le \alpha < 1$).

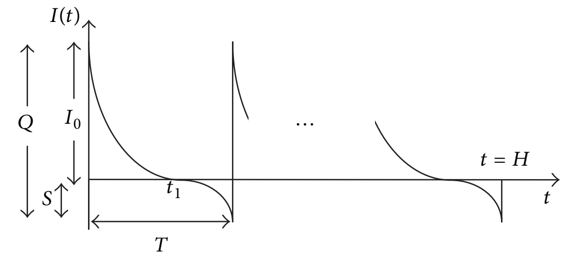

Figure 1: Graphical representation of inventory system.

3. Model Formulation

We use Nakhai and Maihami inventory shortage model [10]. According to this model; the inventory system is as follows: I_0 units of an item arrive at the inventory system at the beginning of each cycle and during the time interval $[0, t_1]$, drop to zero due to demand and deterioration. Finally, a shortage occurs due to demand and partial backlogging during the time interval $[t_1, T]$ (see Figure 1).

The equation representing the inventory status in system for the first interval [10] is as follows:

$$\frac{dI_1(t)}{dt} + \theta d I_1(t) = -D(p,t) \quad 0 \le t \le t_1, \tag{1}$$

when $I_1(t_1) = 0$, inventory level in the $(0, t_1)$ interval yields as the following:

$$I_1(t) = \frac{(a-bp)\,e^{-\theta t}}{\lambda + \theta}\left[e^{(\lambda+\theta)t_1} - e^{(\lambda+\theta)t}\right], \quad 0 \le t \le t_1. \tag{2}$$

Also in this interval with the condition $I_1(0) = I_0$, the maximum inventory level (I_0) yields as follows:

$$I_0 = \frac{(a-bp)}{\lambda+\theta}\left[e^{(\lambda+\theta)t_1} - 1\right]. \tag{3}$$

In the second interval (t_1, T), shortage is partially backlogged according to fraction $\beta(T - t)$. Therefore, the inventory level at time t is obtained by the following:

$$\frac{dI_2}{dt} = -D(p,t)\,\beta(T-t) = \frac{-D(p,t)}{e^{\delta(T-t)}}, \quad t_1 \le t \le T. \tag{4}$$

The solution of the above differential equation, after applying the boundary conditions $I_2(t_1) = 0$, is

$$I_2(t) = \frac{(a-bp)\,e^{-\delta T}\left(e^{(\delta+\lambda)t_1} - e^{(\lambda+\delta)t}\right)}{\lambda+\delta}, \quad t_1 \le t \le T. \tag{5}$$

If we put $t = T$ into $I_2(t)$, the maximum amount of demand backlogging (S) will be obtained:

$$S = -I_2(T) = -\frac{(a-bp)\,e^{-\delta T}\left(e^{(\delta+\lambda)t_1} - e^{(\lambda+\delta)T}\right)}{\lambda+\delta}. \tag{6}$$

Order quantity per cycle (Q) is the sum of S and I_0, that is:

$$Q = S + I_0 = \frac{(a-bp)\,e^{-\delta T}\left(e^{(\delta+\lambda)t_1} - e^{(\lambda+\delta)T}\right)}{\lambda+\delta} + \frac{(a-bp)}{\lambda+\theta}\left[e^{(\lambda+\theta)t_1} - 1\right]. \quad (7)$$

Now, we can obtain the present value of inventory costs and sales revenue for the first cycle, which consists of the following elements.

(1) Since replenishment in each cycle has been done at the start of each cycle, the present value of replenishment cost for the first cycle will be A, which is a constant value.

(2) Inventory occurs during period t_1; therefore, the present value of holding cost (HC) for the first cycle is

$$\mathrm{HC} = c_1\left(\int_0^{t_1} I_1(t)\cdot e^{-r\cdot t}dt\right). \quad (8)$$

(3) The present value of shortage cost (SC) due to backlog for the first cycle is

$$\mathrm{SC} = c_2\left(e^{-r\cdot t_1}\int_{t_1}^{T} -I_2(t)\cdot e^{-r\cdot t}dt\right). \quad (9)$$

(4) The present value of opportunity cost due to lost sales (OC) for the first cycle is

$$\mathrm{OC} = c_3\left(e^{-r\cdot t_1}\int_{t_1}^{T} D(p,t)\left(1-\beta(T-t)\right)\cdot e^{-r\cdot t}dt\right). \quad (10)$$

(5) The present value of purchase cost (PC) for the first cycle is

$$\mathrm{PC} = c\left(I_0 + Se^{-r\cdot T}\right). \quad (11)$$

(6) The present value of return cost (RC) for the first cycle is

$$\mathrm{RC} = (p - \mathrm{SV})\int_0^{t_1}\left(\alpha D(p,t) + \beta p\right)e^{-r\cdot t}dt. \quad (12)$$

(7) The present value of sales revenue (SR) for the first cycle is

$$\mathrm{SR} = p\left(\int_0^{t_1} D(p,t)\cdot e^{-r\cdot t}dt + S\cdot e^{-r\cdot T}\right). \quad (13)$$

There are N cycles during the planning horizon. Since inventory is assumed to start and end at zero, an extra replenishment at $t = H$ is required to satisfy the backorders of the last cycle in the planning horizon. Therefore, the total number of replenishment will be $N + 1$ times; the first replenishment lot size is I_0, and the 2nd, 3rd, …, Nth replenishment lot size is as follows:

$$Q = S + I_0. \quad (14)$$

Finally, the last or $(N+1)$th replenishment lot size is S.

Therefore, the present value of total profit during planning horizon (denoted by $\mathrm{PWTP}(p, t_1, T)$) is derived as follows:

$$\mathrm{PWTP}(p,t_1,T) = \sum_{i=0}^{N-1}(\mathrm{SR} - A - \mathrm{HC} - \mathrm{SC} - \mathrm{OC} - \mathrm{PC} - \mathrm{RC})\,e^{-r.i.T} - A\cdot e^{-r\cdot H}. \quad (15)$$

The value of the variable T can be replaced by the equation $T = H/N$ which uses Maclaurin's approximation for $\sum_{i=0}^{N-1} e^{-r\cdot i\cdot T} \cong 1 - e^{-r\cdot N\cdot T}/1 - e^{-r\cdot T}$. Thus, the objective of this paper is determining the values of t_1, p, and N that maximize $\mathrm{PWTP}(p, t_1, T)$ subject to $p > 0$ and $0 < t_1 < T$, where N is a discrete variable and p and t_1 are continuous variables. For a given value of N, the necessary conditions for finding the optimal p^* and t_1^* are given as follows:

$$\begin{aligned}
\frac{\partial \mathrm{PWTP}}{\partial p}(p,t_1,N) &= -\frac{1}{(-\lambda+r)(\delta+\lambda)\,r\left(-1+e^{-(rH/N)}\right)} \\
&\quad\times\Big(\Big(-re^{-(\delta H/N)}e^{-(rH/N)}(-\lambda+r)(a-bp)\,e^{((\delta+\lambda)H)/N} \\
&\quad + re^{-(\delta H/N)}e^{(\delta+\lambda)t_1}(-\lambda+r)(a-bp)\,e^{-(rH/N)} \\
&\quad + (\delta+\lambda)\Big(r(a-bp)\,e^{-t_1(-\lambda+r)} \\
&\quad + \Big(\Big(((-\mathrm{SV}+2p)\beta + \alpha(a-bp))\,r \\
&\quad -2\left(-\frac{1}{2}\mathrm{SV}+p\right)\lambda\beta\Big)e^{rt_1} \\
&\quad - r\alpha(a-bp)\,e^{\lambda t_1} \\
&\quad -2\left(-\frac{1}{2}\mathrm{SV}+p\right)(-\lambda+r)\,\beta\Big)e^{-rt_1} \\
&\quad -r(a-bp)\Big)\Big)\left(-1+e^{-rH}\right)\Big) = 0,
\end{aligned} \quad (16)$$

$$\begin{aligned}
\frac{\partial \mathrm{PWTP}}{\partial t_1}(p,t_1,N) &= \frac{1}{(r-\delta-\lambda)(-\lambda+r)(\theta+r)(\delta+\lambda)\,r\left(-1+e^{-(rH/N)}\right)} \\
&\quad\times\Big(\Big(-2(\delta+\lambda)\,r(\theta+r)\,e^{-rt_1}(a-bp)\,c_3\left(r-\frac{1}{2}\delta-\frac{1}{2}\lambda\right) \\
&\quad\times(-\lambda+r)\,e^{-(rH/N)}e^{(-t_1(r-\delta-\lambda)N+H(r-\delta))/N}
\end{aligned}$$

Table 1: Optimal solution of the example.

N	p	Time interval t_1	T	Q	PWTP
10	257.5664	2.5798	4	391.0126	32372.5220
11*	**254.8477***	**2.7126***	**3.63***	**392.2260***	**35919.3928***
12	694.1629	0.2142	3.33	107.4832	−161403.4113

$$
\begin{aligned}
&+\Big(2(\delta+\lambda)\Big(r-\frac{1}{2}\delta-\frac{1}{2}\lambda\Big)e^{(t_1(\delta+\lambda)N+rH)/N}\\
&\quad -r^2e^{((\delta+\lambda)H+rt_1N)/N}+e^{t_1(r+\delta+\lambda)}(r-\delta-\lambda)^2\Big)\\
&\times(\theta+r)\,e^{-rt_1}\,(a-bp)\,(-\lambda+r)\,c_2\\
&\times e^{(H(-r-\delta)-rt_1N)/N}+(\delta+\lambda)\\
&\times\Big(2(r-\delta-\lambda)(\theta+r)\\
&\quad\times\Big(-\frac{1}{2}\lambda+r\Big)e^{-rt_1}\,(a-bp)\\
&\quad\times c_3\,e^{-(rH/N)}e^{(-t_1(-\lambda+r)N+rH)/N}\\
&\quad+\Big(e^{t_1(\delta+\lambda)}(-\lambda+r)\\
&\qquad\times(r-\delta-\lambda)(-p+c)\\
&\qquad\times e^{-(\delta H/N)}+r\delta c_3e^{-rt_1}e^{H\lambda/N}\Big)\\
&\quad\times(\theta+r)(a-bp)\,e^{-(rH/N)}-(r-\delta-\lambda)\\
&\quad\times\Big(-(rp+p\theta+c_1)\,(a-bp)\,e^{-t_1(-\lambda+r)}\\
&\quad+(a-bp)\,(c\theta+c_1+rc)\,e^{t_1(\theta+\lambda)}\\
&\quad+(p-\mathrm{SV})\,\Big(\alpha\,(a-bp)\,e^{\lambda t_1}+\beta p\Big)\\
&\quad\times(\theta+r)\,e^{-rt_1}\Big)\,(-\lambda+r)\,\Big)\,r\Big)\\
&\times\Big(-1+e^{-rH}\Big)\Big)=0.
\end{aligned}
\tag{17}
$$

4. Optimal Solution Procedure

The objective function has three variables. The number of replenishments (N) is a discrete variable, the length of time in which there is no inventory shortage (t_1), and the selling price per unit (p). The following algorithm is used to obtain the optimal amount of t_1, p, N [30].

Step 1. let $N = 1$.

Step 2. For different integer N values, derive t_1^* and p^* from (16) and (17). Substitute (p^*, t_1^*, N^*) to (15) to derive $\mathrm{PWTP}(p^*, t_1^*, N^*)$.

Step 3. Add one unit to N and repeat Step 2 for new N. If there is no increase in the last PWPT, then show the last one.

The (p^*, t_1^*, N^*) and $\mathrm{PWTP}(p^*, t_1^*, N^*)$ values constitute the optimal solution and satisfy the following conditions:

$$\Delta\mathrm{PWTP}(p^*, t_1^*, N^*) < 0 < \Delta\mathrm{PWTP}(p^*, t_1^*, N^* - 1), \tag{18}$$

where

$$\Delta\mathrm{PWTP}(p^*, t_1^*, N^*) = \mathrm{PWTP}(p^*, t_1^*, N^* + 1) - \mathrm{PWTP}(p^*, t_1^*, N^*). \tag{19}$$

Substitute (p^*, t_1^*, N^*) to (7) to derive the Nth replenishment lot size.

If the objective function is concave, the following sufficient conditions must be satisfied:

$$\left(\frac{\partial^2\mathrm{PWTP}}{\partial p\partial t_1}\right)^2 - \left(\frac{\partial^2\mathrm{PWTP}}{\partial t_1^2}\right)\left(\frac{\partial^2\mathrm{PWTP}}{\partial p^2}\right) < 0, \tag{20}$$

and any one of the following:

$$\frac{\partial^2\mathrm{PWTP}}{\partial t_1^2} < 0, \qquad \frac{\partial^2\mathrm{PWTP}}{\partial p^2} < 0. \tag{21}$$

Since PWTP is a very complicated function due to high-power expression of the exponential function, it is not possible to show analytically the validity of the above sufficient conditions. Thus, the sign of the above quantity in (21) is assessed numerically. The computational results are shown in the following illustrative example.

5. Numerical Example

To illustrate the solution procedure and the results, let us apply the proposed algorithm to solve the following numerical examples. The results can be found by applying Maple 13. This example is based on the following parameters and functions:

$D(p,t) = (500 - 0.5p)e^{-0.98t}$, c_1 = \$50/per unit/per unit time, c_2 = \$30/per unit/per unit time, c_3 = \$30/per unit, c = \$100/per unit, A = \$30/per order, $\theta = 0.08$, $\beta(x) = e^{0.2x}$, $r = 0.12$, $R(p,t) = 0.2 * D(p,t) + 0.3p$, SV = \$200/per unit, and $H = 40$ unit time.

From Table 1, if all the conditions and constraints in (15)–(21) are satisfied, optimal solution can be derived. In this example, the maximum present value of total profit is found

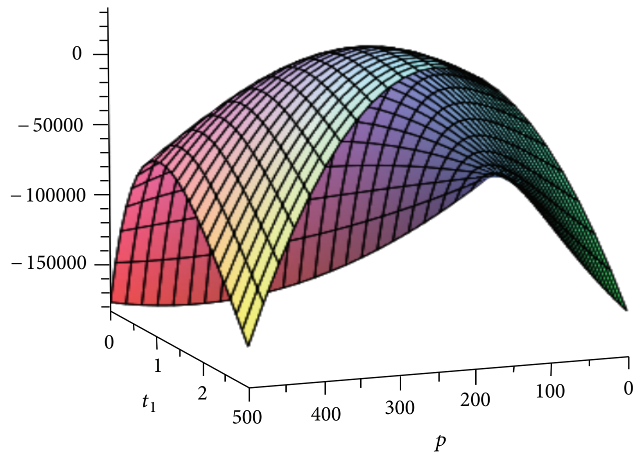

Figure 2: The graphical representation of the concavity of the present worth of total profit function PWTP$(p, t_1, 11)$.

in the 11th cycle. The total number of order is therefore $(N+1)$ or 12. With twelve orders, the optimal solution is as follows:

$$p^* = 254.8477, \qquad t_1^* = 2.7126,$$
$$T^* = 3.63, \qquad \text{PWTP}^* = 35919.3928, \tag{22}$$
$$Q^* = 392.2260.$$

By substituting the optimal values of N^*, p^*, and t_1^* to (21), it will be shown that PWTP is strictly concave (Figure 2):

$$\frac{\partial^2 \text{PWTP}}{\partial t_1^2} = -11764.95287, \qquad \frac{\partial^2 \text{PWTP}}{\partial p^2} = -5.7433. \tag{23}$$

6. Conclusion

In this work, we addressed the problem of joint pricing and inventory control model for deteriorating items taking into account the time value of money and customer returns. The demand is deterministic and depends on time and price simultaneously. Also, the customer returns assumed as a function of both the quantity sold and the price. Shortage is allowed and partially backlogged. An algorithm is presented for deriving the optimal replenishment and pricing policy that wants to maximize the present value of total profit. Finally, a numerical example is provided to illustrate the algorithm and the solution procedure.

This paper can be extended in several ways. For instance, the constant deterioration rate could be extended to a time-dependent function. Also, the deterministic demand function could be extended to the stochastic demand function. Finally, we could extend the model to incorporate some more realistic features such as quantity discounts and permissible delay in payments.

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References

[1] H. M. Wee, "Economic production lot size model for deteriorating items with partial back-ordering," *Computers and Industrial Engineering*, vol. 24, no. 3, pp. 449–458, 1993.

[2] P. M. Ghare and G. H. Schrader, "A model for exponentially decaying inventory system," *International Journal of Production Research*, vol. 21, pp. 449–460, 1963.

[3] R. P. Covert and G. C. Philip, "An EOQ model for items with Weibull distribution deterioration," *AIIE Transactions*, vol. 5, no. 4, pp. 323–326, 1973.

[4] S. K. Goyal and B. C. Giri, "Recent trends in modeling of deteriorating inventory," *European Journal of Operational Research*, vol. 134, no. 1, pp. 1–16, 2001.

[5] P. L. Abad, "Optimal pricing and lot-sizing under conditions of perishability and partial backordering," *Management Science*, vol. 42, no. 8, pp. 1093–1104, 1996.

[6] P. L. Abad, "Optimal price and order size for a reseller under partial backordering," *Computers and Operations Research*, vol. 28, no. 1, pp. 53–65, 2001.

[7] C. Y. Dye, "Joint pricing and ordering policy for a deteriorating inventory with partial backlogging," *Omega*, vol. 35, no. 2, pp. 184–189, 2007.

[8] C. Y. Dye, L. Y. Ouyang, and T. P. Hsieh, "Inventory and pricing strategies for deteriorating items with shortages: a discounted cash flow approach," *Computers and Industrial Engineering*, vol. 52, no. 1, pp. 29–40, 2007.

[9] H. J. Chang, J. T. Teng, L. Y. Ouyang, and C. Y. Dye, "Retailer's optimal pricing and lot-sizing policies for deteriorating items with partial backlogging," *European Journal of Operational Research*, vol. 168, no. 1, pp. 51–64, 2006.

[10] K. I. Nakhai and R. Maihami, "Joint pricing and inventory control for deteriorating items with partial backlogging," *International Journal of Industrial Engineering and Production Management*, vol. 21, pp. 167–177, 2011.

[11] Y. C. Tsao and G. J. Sheen, "Dynamic pricing, promotion and replenishment policies for a deteriorating item under permissible delay in payments," *Computers and Operations Research*, vol. 35, no. 11, pp. 3562–3580, 2008.

[12] B. Sarkar, "An EOQ model with delay in payments and stock dependent demand in the presence of imperfect production," *Applied Mathematics and Computation*, vol. 218, pp. 8295–8308, 2012.

[13] B. Sarkar, "An EOQ model with delay in payments and time varying deterioration rate," *Mathematical and Computer Modelling*, vol. 55, pp. 367–377, 2012.

[14] B. K. Sett, B. Sarkar, and A. Goswami, "A two-warehouse inventory model with increasing demand and time varying deterioration," *Scientia Iranica E*, vol. 19, no. 6, pp. 1969–1977, 2012.

[15] B. Sarkar, S. S. Sana, and K. Chaudhuri, "An economic production quantity model with stochastic demand in an imperfect production system," *International Journal of Services and Operations Management*, vol. 9, no. 3, pp. 259–283, 2011.

[16] J. A. Buzacott, "Economic order quantity with inflation," *Operational Research Quarterly*, vol. 26, no. 3, pp. 553–558, 1975.

[17] R. B. Misra, "A note on optimal inventory management under inflation," *Naval Research Logistics Quarterly*, vol. 26, no. 1, pp. 161–165, 1979.

[18] F. Jolai, R. Tavakkoli-Moghaddam, M. Rabbani, and M. R. Sadoughian, "An economic production lot size model with deteriorating items, stock-dependent demand, inflation, and partial backlogging," *Applied Mathematics and Computation*, vol. 181, no. 1, pp. 380–389, 2006.

[19] K. S. Park, "Inflationary effect on EOQ under trade-credit financing," *International Journal on Policy and Information*, vol. 10, no. 2, pp. 65–69, 1986.

[20] T. K. Datta and A. K. Pal, "Effects of inflation and time-value of money on an inventory model with linear time-dependent demand rate and shortages," *European Journal of Operational Research*, vol. 52, no. 3, pp. 326–333, 1991.

[21] S. Goel, Y. P. Gupta, and C. R. Bector, "Impact of inflation on economic quantity discount schedules to increase vendor profits," *International Journal of Systems Science*, vol. 22, no. 1, pp. 197–207, 1991.

[22] R. W. Hall, "Price changes and order quantities: impacts of discount rate and storage costs," *IIE Transactions*, vol. 24, no. 2, pp. 104–110, 1992.

[23] B. R. Sarker and H. Pan, "Effects of inflation and the time value of money on order quantity and allowable shortage," *International Journal of Production Economics*, vol. 34, no. 1, pp. 65–72, 1994.

[24] M. A. Hariga and M. Ben-Daya, "Optimal time varying lot-sizing models under inflationary conditions," *European Journal of Operational Research*, vol. 89, no. 2, pp. 313–325, 1996.

[25] I. Horowitz, "EOQ and inflation uncertainty," *International Journal of Production Economics*, vol. 65, no. 2, pp. 217–224, 2000.

[26] I. Moon and S. Lee, "Effects of inflation and time-value of money on an economic order quantity model with a random product life cycle," *European Journal of Operational Research*, vol. 125, no. 3, pp. 558–601, 2000.

[27] A. Mirzazadeh and A. R. Sarfaraz, "Constrained multiple items optimal order policy under stochastic inflationary conditions," in *Proceedings of the 2nd Annual International Conference on Industrial Engineering Application and Practice*, pp. 725–730, San Diego, Calif, USA, November 1997.

[28] J. K. Dey, S. K. Mondal, and M. Maiti, "Two storage inventory problem with dynamic demand and interval valued lead-time over finite time horizon under inflation and time-value of money," *European Journal of Operational Research*, vol. 185, no. 1, pp. 170–194, 2008.

[29] A. Mirzazadeh, M. M. S. Esfahani, and S. M. T. F. Ghomi, "An inventory model under uncertain inflationary conditions, finite production rate and inflation-dependent demand rate for deteriorating items with shortages," *International Journal of Systems Science*, vol. 40, no. 1, pp. 21–31, 2009.

[30] H. M. Wee and S. T. Law, "Replenishment and pricing policy for deteriorating items taking into account the time-value of money," *International Journal of Production Economics*, vol. 71, no. 1–3, pp. 213–220, 2001.

[31] T. P. Hsieh and C. Y. Dye, "Pricing and lot-sizing policies for deteriorating items with partial backlogging under inflation," *Expert Systems With Applications*, vol. 37, pp. 7234–7242, 2010.

[32] B. Sarkar and I. Moon, "An EPQ model with inflation in an imperfect production system," *Applied Mathematics and Computation*, vol. 217, no. 13, pp. 6159–6167, 2011.

[33] B. Sarkar, S. S. Sana, and K. Chaudhuri, "An imperfect production process for time varying demand with inflation and time value of money—an EMQ model," *Expert Systems with Applications*, vol. 38, no. 11, pp. 13543–13548, 2011.

[34] B. Sarkar, S. S. Sana, and K. Chaudhuri, "A finite replenishment model with increasing demand under inflation," *International Journal of Mathematics and Operational Research*, vol. 4, no. 2, pp. 347–385, 2010.

[35] J. D. Hess and G. E. Mayhew, "Modeling merchandise returns in direct marketing," *Journal of Interactive Marketing*, vol. 11, no. 2, pp. 20–35, 1997.

[36] E. T. Anderson, K. Hansen, D. Simister, and L. K. Wang, "How are demand and returns related? Theory and empirical evidence," Working Paper, Kellogg School of Management, Northwestern University, 2006.

[37] J. Chen and P. C. Bell, "The impact of customer returns on pricing and order decisions," *European Journal of Operational Research*, vol. 195, no. 1, pp. 280–295, 2009.

[38] B. A. Pasternack, "Optimal pricing and returns policies for perishable commodities," *Marketing Science*, vol. 4, no. 2, pp. 166–176, 1985.

[39] S. X. Zhu, "Joint pricing and inventory replenishment decisions with returns and expediting," *European Journal of Operational Research*, vol. 216, pp. 105–112, 2012.