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An inventory model with discount for imperfect items and purchasing price dependent demand

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Abstract

A special price discount is used to motivate buyers in nowadays. At the same time, that discount do not affect the profit. So in this model, the one - time only - discount is given to the imperfect items. This improves the profit of this model. Because these imperfect items are usually considered as deteriorating items which leads to deterioration loss. Also demand depends on purchasing price in real life. So purchasing price dependent demand is considered. The lot size and time length of the cycle are optimized. A sensitivity analysis is presented to illustrate the parameters of this model.

Keywords

Imperfect items, economic order quantity, screening process, one - time – only discount.

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1. Introduction

The EOQ (economic order quantity) inventory control model was introduced in the earliest decades of this inventory, it is still widely accepted by many researchers today. Regardless of such an acceptance, the analysis for finding an economic order quantity has several weakness. This has shepherded many researchers to study the EOQ extensively under real life situations.

Ozer Ozturk, Yavug Gazitbey and Orhan Gerdan [5] examined fuzzy optimal production and shortage quantity for fuzzy production inventory with backorder. The two different fuzzy models, one of which includes crisp production and crisp shortage quantity, and the other of which involves those that are fuzzy, have been presented by making use of trapezoidal fuzzy numbers are discussed.

A common unrealistic assumption in using the EOQ is that all units purchased are of good quality. Later, all the defective items, as a result of considering imperfect quality purchase process were considered as deteriorating items. The analysis of deteriorating inventory model is intiated by Ghare and Schrader [3] with a constant rate of decay. After this, more models are developed for deteriorating items. Dr.M.Maragatham, Dr.P.K.Lakshmidevi [2] discussed the fuzzy model with changing deterioration rate. Two different rates of deterioration are allowed at the time of transportation and demand. Tersine and Barman [7] studied the problem of scheduling replenishment orders under the classical EOQ model when both quantity and freight rate discounts are encountered. Yanlai Liang, Fangning Zhou [9] developed a two warehouse inventory model for deteriorating items under conditionally permissible delay in payment.

All the items of imperfect quality, not necessarily deteriorated, could be used. Some people are willing to purchase acceptable imperfect quality items with discounts. So the traditional EOQ model by accounting for imperfect quality items is extended.

Ritha.W, Nithya.K [6] developed fuzzy inventory model with imperfect items under one time only discount. Two fuzzy inventory models are discussed with fuzzy parameters for crisp order quantity or fuzzy order quantity in order to extend the order quantity inventory model to the fuzzy environment.

In this paper, an inventory model having imperfect items with the purchasing price dependent demand is discussed. The issue that imperfect quality items are sold as a single batch by the end of the 100% screening process is considered here.

This model is solved analytically to determine the optimal lot size and the optimal cycle time. The numerical examples and sensitivity analysis are provided to illustrate the solution procedure.

2. Model formulation

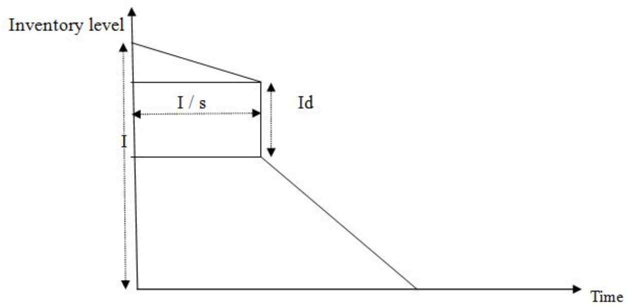

Figure 1. The behavior of the inventory model

A lot size is delivered instantaneously with purchasing price p per unit. It is assumed that each lot received contains imperfect items with percentage d. These imperfect items are sold as single batch with discounted price. A 100% screening process of the lot is conducted at a rate of s units per unit time. The items of imperfect quality are kept in stock and sold prior to receiving the next shipment as a single batch at a discounted price. The demand is always price dependent in real life. So purchasing price dependent demand is considered in this model.

3. Notations

T - Cycle length

I - Lot size

p -Purchasing cost per unit

$\lambda_1 + \lambda_2 p$ - Demand rate, $\lambda_1, \lambda_2 > 0$

d - Defective percentage

s - Screening rate, $s > \lambda_1 + \lambda_2 p$

S_1 - Selling price per unit of good quality

S_2 - Selling price per unit of imperfect quality

w - Screening cost per unit

O - Ordering cost per order

h - Holding cost per unit

TR(I) - Total revenue per cycle

$TE(I)$ - Total expenditure per cycle

TP(I) - Total profit per cycle

TPU(I) - Total profit per unit time

4. The costs involved in this cycle

The ordering cost per cycle $= O$
The purchasing cost per cycle $= pI$
The screening cost per cycle $= wI$

$$\text{The holding cost per cycle } = h\left[\frac{I(1-d)T}{2} + \frac{dI^2}{s}\right]$$

$$= h\left[\frac{I^2(1-d)^2}{2(\lambda_1+\lambda_2 p)} + \frac{dI^2}{s}\right]$$

$$\left.\begin{array}{c}\text{The selling price of good}\\ \text{quality items per cycle}\end{array}\right\} = s_1 I(1-d)$$

$$\left.\begin{array}{c}\text{The selling price of}\\ \text{imperfect}\\ \text{quality items per cycle}\end{array}\right\} = s_2 Id$$

$$\left.\begin{array}{c}\text{Total revenue per cycle}\\ \text{TR}(I)\end{array}\right\} = s_1 I(1-d) + s_2 Id$$

$$\left.\begin{array}{c}\text{Total expenditure per cycle}\\ TE(I)\end{array}\right\}$$

$$= 0 + pI + wI + h\left[\frac{I^2(1-d)^2}{2(\lambda_1+\lambda_2 p)} + \frac{dI^2}{s}\right]$$

$$\text{Total profit per cycle } TP(I) = S_1 I(1-d) + s_2 Id$$

$$-\left[O + pI + wI + h\left[\frac{I^2(1-d)^2}{2(\lambda_1+\lambda_2 p)} + \frac{dI^2}{s}\right]\right]$$

$$\left.\begin{array}{c}\text{Total profit per unit time}\\ \text{TPU}(I)\end{array}\right\} = \frac{TP(I)}{T}$$

$$= S_1(\lambda_1+\lambda_2 p) + \frac{s_2 d}{(1-d)}$$

$$-\left[\frac{(\lambda_1+\lambda_2 p)0}{I(1-d)} + \frac{p(\lambda_1+\lambda_2 p)}{1-d} + \frac{w(\lambda_1+\lambda_2 p)}{1-d}\right.$$

$$\left.+\frac{hI(1-d)}{2} + \frac{hdI(\lambda_1+\lambda_2 p)}{s(1-d)}\right]$$

Then

$$\frac{dTPU(I)}{dI} = \frac{\lambda O}{I^2(1-d)} - \frac{h(1-d)}{2} - \frac{hd\lambda}{s(1-d)}$$

$$\frac{d^2 TPU(I)}{dI^2} = \frac{-2\lambda O}{I^3(1-d)}$$

For maximum profit, $\frac{dTPU(I)}{dI} = 0$

$$(ie),\quad \frac{\lambda 0}{I^2(1-d)} - \frac{h(1-d)}{2} - \frac{hd\lambda}{s(1-d)} = 0$$

Then we get

$$I = \sqrt{\frac{2\lambda Os}{h[\,s(1-d)^2 + 2\,d\lambda]}}$$

The length of the cycle

$$T = \frac{I(1-d)}{\lambda}$$

5. Numerical example

Consider $p = 12$ per unit, $\lambda_1 = 2000$ units per year, $\lambda_2 = 200$ units per year, $d = 0.1, s_1 = 50$ perunit, $s_2 = 30$ per unit, $w = 2$ per unit, $s = 20000$ units per year , $O = 80$ per cycle, $h = 0.5$ per unit .
Then the optimal values
Lot size $I = 1284$ units
Total profit per unit time $TPU(I) = 150950$
Cycle length $T = 0.2626$ year $= 3.15 months$

Sensitivity analysis on λ_1			
λ_1	I	T (months)	TPU
2000	1284	3.15	150950
2100	1297.8	3.11	154390
2200	1311.3	3.08	157820
2300	1324.7	3.04	161260
2400	1338	3.01	164700

Sensitivity analysis on λ_2			
λ_2	I	T (months)	TPU
200	1284	3.15	150950
300	1438.5	2.77	192200
400	1574.3	2.5	233460
500	1696	2.29	274720
600	1806.6	2.12	315990

Sensitivity analysis on s			
s	I	T(months)	TPU
20000	1284	3.15	150950
15000	1273.1	3.13	150940
10000	1252.2	3.07	150930
8000	1237.1	3.04	150930
5000	1195	2.93	150900

Sensitivity analysis on p			
p	I	T(months)	TPU
12	1284	3.15	150950
13	1311.3	3.08	152710
14	1338	3.01	154030
15	1364	2.95	154910
16	1389	2.89	155340

Sensitivity analysis on d			
d	I	T (months)	TPU
0.1	1284	3.15	150950
0.2	1390.7	3.03	142370
0.3	1504.5	2.87	131340
0.4	1620.8	2.65	116630
0.5	1730.8	2.36	96017

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