Manufacturer – Buyer coordination inventory model with screening process and shortages

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ABSTRACT

This study focuses on the coordination and non-coordination of situations for the buyer and manufacturer. For the bulk purchase, the manufacturer supplies discount quantity in coordinate situations. For buyer and manufacturer total cost is developed in both the situations and optimal order quantity is determined to minimize the inventory cost. The developed model revels to provide the numerical examples.

Keywords: Production, Inventory, Coordination, Order quantity, Screening cost.

1. INTRODUCTION

Demand is not suitable and predictable in most of the industries. So, ordering of goods in correct quantity on correct time becomes extremely important. This paper preserves a model for deciding the ordering policy which would reduce the total inventory cost. The most commonly used inventory control technique is the economic production quantity technique. If faulty goods are to be either repaired or kept in stock or castaway.

Chen et al. [1] developed modified economic production and raw material model with quality loss for conforming product. Jauhari et al. [2] studied an integrated inventory model for single-vendor single-buyer system with freight rate discount and stochastic demand. Liang-Yuh Ouyang and Hung-Chi Chang [3] analyzed the variable lead time stochastic inventory model with a fuzzy backorder rate. Kaur et al. [4] studied optimal ordering policy with non-increasing demand for time dependent deterioration under fixed life time production and permissible delay in payments. Ravithammal et al. [5] considered obtaining inventory model for price discount with shortage. Ravithammal et al. [6] developed a deterministic production inventory model for buyer- manufacturer with quantity discount and completely backlogged shortages for fixed life time product. Ravithammal et al. [6] studied an integrated production inventory system for perishable items with fixed and linear backorders. Sana [8] analyzed an economic production lot size model in an imperfect production system. Tiwari et al. [9] developed impact of trade credit and inflation on retailer's ordering policies for non-instantaneous deteriorating items in a two-warehouse environment. Yoo et al. [10] considered inventory models for imperfect production and inspection processes with various inspection options under one-time and continuous improvement investment.

2. ASSUMPTIONS AND NOTATIONS

The model use the following notations and assumptions

Notations

D	Demand rate
P	Production rate
R_1	Buyer's unit ordering cost
R_2	Manufacturer unit setup cost
s	Buyer's unit shortage cost
p	Buyer's unit purchase cost
Q	Economic Order quantity
Q_1	Backorders level
H_b	Buyer's unit holding cost
H_v	Manufacturer unit holding cost
s_c	Manufacturer unit screening cost
n	Manufacturer multiples of order for non-coordination
m	Manufacturer multiples of order for coordination
k	Buyer's multiples of order for coordination
d (k)	Discount factor

Assumptions

(i) Demand rate is constant.
(ii) In non-coordination, manufacturer produced the product and buyer has shortage.
(iii) In coordination, manufacturer produced the product and buyer has no shortage and also manufacturer provides the quantity discount to the buyer.

3. MODEL FORMULATION

In this section, non-coordination model with shortage and coordination model without shortage are considered. In case 1, manufacturer produced the items and buyer having shortage and in case 2, buyer has no shortage and manufacture offer quantity discount to the buyer. Thus for both cases, the total cost will write as follows:

Case 1: Non coordination model with shortage

The total cost for buyer contains, ordering cost $\frac{R_1 D}{Q}$, holding cost $\frac{H_b Q_1^2}{2Q}$ and shortage cost $\frac{s(Q-Q_1)^2}{2Q}$ and it can be written as

$$TC_b = \frac{R_1 D}{Q} + \frac{H_b Q_1^2}{2Q} + \frac{s(Q-Q_1)^2}{2Q}$$

The total cost for manufacturer contains the setup cost $\frac{R_2 D}{nQ}$, the holding cost $\frac{H_v nQ}{2}\left(1-\frac{D}{P}\right)$ and the screening cost $\frac{s_c nQ}{2}$ and it can be written as

$$TC_m = \frac{R_2 D}{nQ} + \frac{H_v nQ}{2}\left(1-\frac{D}{P}\right) + \frac{s_c nQ}{2}$$

Integrated system cost can be written as

$$TC_s = TC_b + TC_m$$

$$\text{i.e., } TC_s = \frac{D}{Q}\left(R_1 + \frac{R_2}{n}\right) + \frac{H_b Q_1^2}{2Q} + \frac{s(Q-Q_1)^2}{2Q} + \frac{H_v nQ}{2}\left(1-\frac{D}{P}\right) + \frac{s_c nQ}{2} \quad (1)$$

For optimality $\frac{\partial TC_s}{\partial Q_1} = 0$ and $\frac{\partial^2 TC_s}{\partial Q_1^2} > 0$ we get,

$$Q_1^* = \frac{sQ}{H_b + s} \quad (2)$$

For optimality $\frac{\partial TC_m}{\partial Q} = 0$ and $\frac{\partial^2 TC_m}{\partial Q^2} > 0$ we get,

$$Q^* = \sqrt{\frac{2D\left(R_1 + \frac{R_2}{n}\right)(H_b + s)}{sH_b + \left(nH_v\left(1-\frac{D}{P}\right) + ns_c\right)(H_b + s)}} \quad (3)$$

Case 2: Coordination model with no shortage

The total cost for buyer contains, ordering cost $\frac{R_1 D}{Q_c}$, holding cost $\frac{H_b Q_c}{2}$ and screening cost $\frac{s_c Q_c}{2}$ and it can be written as

$$TC_{b1} = \frac{R_1 D}{Q_c} + \frac{H_b Q_c}{2} + \frac{s_c Q_c}{2}$$

The total cost for manufacturer contains, setup cost $\frac{R_2 D}{kmQ_c}$, holding cost $\frac{H_v kmQ_c}{2}\left(1-\frac{D}{P}\right)$ and buyer's quantity discount pDd(k) and it can be written as

$$TC_{m1} = \frac{R_2 D}{kmQ_c} + \frac{H_v kmQ_c}{2}\left(1-\frac{D}{P}\right) + pDd(k)$$

Integrated system cost can be written as

$$TC_{s1} = TC_{b1} + TC_{m1}$$

$$TC_{s1} = \frac{D}{Q_c}\left(R_1 + \frac{R_2}{km}\right) + \frac{Q_c}{2}(H_b + s_c) + \frac{H_v kmQ_c}{2}\left(1-\frac{D}{P}\right) + pDd(k) \quad (4)$$

For optimality $\frac{\partial TC_{s1}}{\partial Q_c} = 0$ and $\frac{\partial^2 TC_{s1}}{\partial Q_c^2} > 0$ we get,

$$Q_c^* = \sqrt{\frac{2D\left(R_1 + \frac{R_2}{km}\right)}{H_b + s_c + kmH_v\left(1-\frac{D}{P}\right)}} \quad (5)$$

4. NUMERICAL EXAMPLE

Let $R_1 = 300$ per order, $R_2 = 100$ per order, D = 1000 units per year, P = 2000, $H_v = 0.04$, $H_b = 0.02$, $s_c = 0.2$, s = 0.25, p = 0.5, n = 4, m=3, k= 2, d(k) = 5%.

The optimal solutions are

$Q^* = 850.54, Q_1^* = 787.53, TC_s = 764.22, Q_c^* = 1364.8, TC_{s1} = 564.82$

5. CONCLUSION

In this study, manufacturer - buyer inventory model is developed under shortage and screening process. Under non coordination, shortages are allowed for buyer. In coordination, manufacturer offer quantity discount to buyer for more purchase. To compare with non-coordination, coordination situation proves more benefits. Our aim is to compute the optimal order quantity to minimize the total inventory cost. Further the proposed model can be extended to consider one time discount, temporary discount and price discount etc.,

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