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A Two –Item Deterministic EOQ Model with Partial Backordering and Substitution with Stock – Dependent Demand

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ABSTRACT

This study discussed about the two item deterministic EOQ model where the demand of one product is partially back ordered when stock-dependent demand is raised and due to backorder part of its lost sales can be satisfied with the substitute product. The main aim of this model is to considering the importance of substitute product and demand or utilization during the era of backorder of main product.

KEYWORDS:EOQ Model, Two – items, Partial backordering and substitution, Stock dependent demand

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INTRODUCTION:

Simple theory of conceivers attitude about product is classifying in two ways during the stock out (1) it may about their waiting till replenishment and (2) they may go with the other product. Montgomery et-al (1973) discussed first time about the EOQ with study of partial backordering.After that Rosenberg (1979), Park (1982) and Pentico and drake (2009) presented similar models related to back ordering.

If an inventory can be maintained with similar product, it may reduce the backordering problem as well loss of consumers. The base literature of the same theory studied by [2] with an assumption that the unmet demand can be satisfied with similar product. Many literatures have been considered study the same problem after them[3, 4.] Study of demand substitution in stock out situations.[5, 6, 7] Inventory model with stock dependent demand have concerned the interest of researchers in recent years.

In this paperdeterministic EOQ model deal with two items which partially backordering and substitute when demand depends upon stock an inventory model has developed.Numerical studies of this model have been demonstrated and justify optimality condition of β.

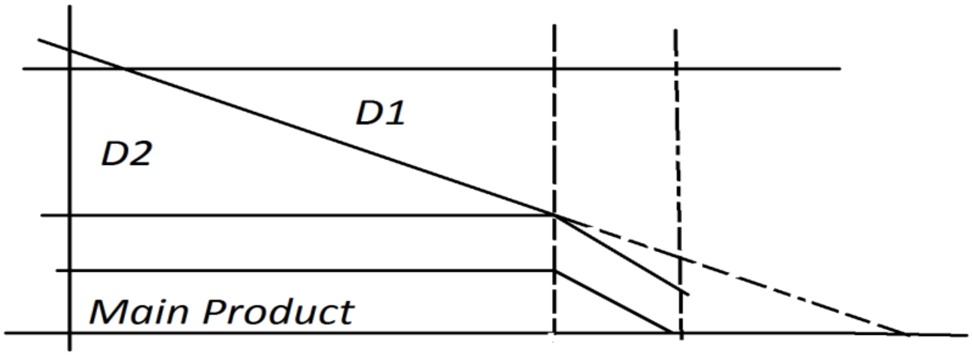

Figure1.Inventory of Main Product with Back Order

Parameters:

D = Demand per unit in inventory

C_h = Holding Cost

C_b = Backordering Cost

C_o = Opportunity Cost

α = Fraction of Major Product

β = Fraction of Substitute Product

d_1 = First Slot substitute Product Demand

d_2 = Second Slot substitute after Demand of replenishment or Backorder

A_1 = Cost of placing order for stocked out products

C_{h1} = per unit holding cost for substitute product

C_s = Cost to Substitute item

a_1 = Cost to substitute product in first back order of demand

a_2 = Cost to substitute product in second back order of demand

T = Order Cycle

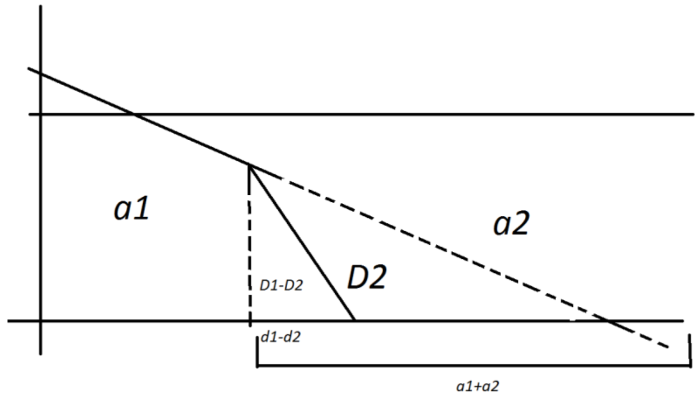

Figure2. Inventory Time Back Ordering to Second Product or Minor Product (d_2)

Assumptions:

1. The demand rate of two product are constant
2. Replenishment is instantaneous
3. The lead time is zero
4. The demand rate D_i (I = 1,2 ..)for each product occupancy is a function of instantaneous stock level $l_{i\,(t)}$ of both product at a given era of time as:

$$D_1(t) = a_1 + b_1 l_1(t) - b_2 l_2(t)$$

and

$$D_2(t) = a_2 + b_1 l_1(t) - b_2 l_2(t)$$

$$0 \leq t \leq T, a > 0, 0 < b < 1$$

5. At time t_1 the stock of first product times out and become zero seems to be $t_1 \leq t \leq T$is known as function x of the excess demand and met by using the stock of substitute product.
6. The ending product stock of substitute item classifies in two stems and could be greater than 0.
7. The costs different between first and second stock out of substitute product remains the same
8. There is capacity restriction that $l_1(0) + l_2(0) \leq 0$

MATHEMATICAL MODEL:

An EOQ model of two items with partial backorder and substitution

$$Z\ (T,F) = \frac{a_1 + a_2 + A_1}{T} + [C_h - \propto C_{h1} + BC_b]BC_b(d_1 + d_2)TF + \frac{(d_1 + d_2)TF^2}{2}$$
$$- [(1-\beta)C_0 + \alpha C_s](d_1 + d_2)(1-F)$$
$$+ \frac{Cb_1[(d_1 + d_2) + \alpha(d_1 + d_2)] + \beta C_b\,(d_1 + d_2)T}{2}$$

Now,$d_1 l(t_1) = -D_1(t) = -a_1 - b_1 l_1(t_1) + b_2 l_2(t_2)$

Both,$0 \le t \le t_1, 0 \le t \le t_2$

The substitute slabs (d1 and d2) can be determines at time t as the first or main product reaches to zero and fraction x of the excess demand is met by using stock of substitute products containing cost of holding a1 and a2.

$$\frac{d_2 l_2(t_2)}{d_t} = -D_2(t_2) - xD_2(t_2)$$
$$= -(a_2 + xa_1) - b_2(1-x)l_2(t)$$

Here, $t_1 \le t \le T$

Now, $(T,F) = \frac{a_1+a_2+A_1}{T} + [C_h - \propto C_{h1} + BC_b]BC_b(d_1 - a_2 + xa_1) - b_2(1-x)l_2(t)(1-F) + \frac{Cb_1[(d_1+(a_2+xa_1) - b_2\,(1-x)l_2(t)}{2}$

Now,

$$\frac{\partial Z}{\partial T} = \frac{a_1 + a_2 + A_1}{(d_1 + d_2)} \cdot \frac{(b - \alpha Cb_1 + \beta C_b)}{\frac{(d_1+d_2)}{(d_1-d_2)} + \alpha\,(C_h - \alpha C_{h1}) + \beta C_b(C_h + dC_{h1})}$$
$$- \frac{[(1-\beta)C_0 + \alpha C_s]^2}{\left[\frac{(d_1+d_2)}{(d_1-d_2)} + \alpha\,(C_h - \alpha C_{h1}) + \beta C_b C_{h1}(C_h + (d_1 + d_2))\right]^{\frac{1}{2}}}$$

And

Type equation here.

$$\frac{\partial Z}{\partial T} = \frac{\beta C_b\left(\frac{\partial Z}{\partial T}\right) + (1-\beta)C_0 + \alpha C_s}{(C_h - \alpha C_{h1} + \beta C_b)\left(\frac{\partial Z}{\partial F}\right)}$$

Relatively the product quality for main product and steam substitute product can be presented as:

1. $Q_1^* = \left[(d_1 + d_2) + \propto\ (d_1 + d_2)(1 - F^*)\left(\frac{\partial Z}{\partial T}\right)\right]$ and
2. $Q_2^* = \left[(d_1 + d_2) +\ xl_2(t_2)(d_1 + d_2)(1 - F^*)\left(\frac{\partial Z}{\partial T}\right)\right]$

Numeric Study:

Suppose,

$$a_1 = 0.4, a_2 = 0.6,\ A_1 = 200, d_1 = 100, d_2 = 50, C_h = 20, C_b = 2, C_0 = 10, C_{h1} = 1, C_{b1} = 4, b = 40.4, \propto = 0.3, \quad \beta\ can\ be\ C_s = 4.5$$

Determine as,

$$\frac{0.4 + 0.6 + 200}{100 + 50} \cdot \frac{(40.4 - 0.3(4) + \beta(2)}{\frac{(100+50)}{(100-50)} + 0.3(20 - (0.3)(20)} - \frac{[(1-\beta)10 + 0.3(4.5)]^2}{\left[\frac{(100+50)}{(100-50)} + 0.3[0.3 - (0.3)(20)](20) + \beta(1 + (100 + 50)(1)(2)\right]^{1/2}}$$

Based $\propto, \beta = 0.645$ now, β^* can be determine

$$\beta^* = (C_0 + \propto C_s)(d_1 + d_2) + \sqrt{2\,(a_1 + a_2)C_{h1}(d_1 + d_2) + \propto (d_1 + d_2)}$$

$$= [10 + 0.3(4.5)](100 + 50) + \sqrt{2\,(0.4 + 0.6)(1)100 + 50) + 0.3(100 + 50)}$$

$$\therefore \beta^* = 0.720$$

Here,$\beta > \beta^*$ is the optimal condition of backordering

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