ISSN: 2321-7782 (Online)
Volume 2, Issue 1, January 2014
International Journal of Advance Research in Computer Science and Management Studies
Research Paper
Available online at: www.ijarcsms.com

Determination of Supplier's Economic Ordering Policy in Just-In-Time System with Varying Ordering Cost

Dr. Kavita Dave
Head and Ph.D Guide
Statistics Department
S. M. Patel Institute of Commerce
Ahmedabad - India

Abstract: This paper deals with the purchasing aspect of Just-In-Time (JIT) considering varying setup costs. The various features of the JIT purchasing like frequent deliveries of small shipments, reduction in the inventories are taken into consideration. Here we deal with determination economic order quantity under JIT purchasing having varying setup cost when demand is fixed and varying. In both cases it is observed that with increase in optimum number of shipments results in decrease in total cost. Also increase in contract quantity results in significant decrease in total cost. Also we have developed a model which shows the determination of economic order quantity for perishable product. The perishable product cannot be held for a long time and hence JIT is the best suitable which reduces the amount of inventory and its cost significantly.

Keywords: ordering cost, EOQ, JIT, inventory.

I. INTRODUCTION

This model concerns with the determination of suppliers' economic ordering policy, which in turn reduces the buyers' cost. As not much literature is available regarding this problem where both the buyer and the supplier are treated simultaneously. However this model reflects how compensation given by the supplier helps the buyer to order more and stick to a single source of supply. Goyal (1973) presented an integrated model of the suppliers' and buyers' inventory problem which results in lower total joint costs for the buyer and the supplier Monahan (1984) suggested offering quantity discount to the buyer in order to induce to buy in quantities suitable to the buyer. He determined a breakeven price discount, which would compel the buyer to buy in quantities desirable to the supplier.Goyal (1973) also formulated the suppliers' inventory problem assuming the case of mono buyer and mono supplier. Here model is developed under JIT environment having single buyer and single supplier that is having single source of supply. Here buyer orders in quantities just as needed hence buyer's inventory level is reduced and supplier does not need to keep excessive inventory.

II. NOTATIONS

Q: Contract quantity (units)

D: Annual demand

N: Number of shipments per contract

A: Cost of placing an order (Rs./order)

p: Unit purchase price

H: Inventory holding cost (Rs/unit/year) (Average inventory is Q/2N)

P: Aggregate cost per shipment

b: Positive constant

Assumptions:

Demand is constant.

Shortages are not allowed.

Lead time is zero.

III. PROBLEM FORMULATION

The buyer's annual cost B is given by

$$B = Dp + (A + NP + bQ)\frac{D}{Q} + \frac{QH}{2N}$$

Where 'A' and 'b' are constants. The E.O.Q. Q_0 and the minimum total cost B_0 for the buyer are given by

$$Q_o = \sqrt{\frac{2DH(A+NP)}{N}} \quad (1)$$

and $$B_o = D(b+p) + \sqrt{\frac{2DH(A+NP)}{N}} \quad (2)$$

Let $G = \sqrt{\frac{2DH(A+NP)}{N}}$. Therefore $B_0 = D(b+p) + G$. If the supplier wishes that the buyer should buy in quantities different from Q_0, he must compensate the buyer with an amount equal to $(B-B_0)$ in order to reduce the increased costs incurred by the buyer. Therefore the total compensation payable to the buyer is

$$X(Q) = c\left(\frac{D(A+NP)}{Q} + \frac{QH}{2N} - G\right) \quad (3)$$

Where 'c' is a constant dependent on the relationship between the buyer and the supplier. In order to have a sound relationship between the buyer and the supplier, we have $c \geq 1$. For the supplier, the various cash flow are as follows:

Cost of buying the items = DC

Sales revenue =Dp

Compensation paid to the buyer = X(Q) [from (3)]

Ordering cost = $\frac{D(A_1 + b_1Q + NP)}{KQ}$

Where K is a positive integer. Inventory cost = $\frac{(K-1)QH_1}{2N}$

where,

C = Unit cost paid by the supplier.

(A_1+NP+b_1Q) = Cost of placing a purchase order for the supplier.

H_1 = Unit holding cost per year for the supplier.

The annual profit of the supplier, Z equals

$$D(p-C)+c\left(\frac{D(A+bQ+NP)}{Q}+\frac{QH}{2N}-G\right)-\frac{D(A_1+b_1Q+NP)}{KQ}-\frac{(K-1)\,QH_1}{2N} \qquad (4)$$

This can be simplified as

$$Z=D(P-C)-cG-\frac{D}{G}\left(c(A+bQ+NP)+\frac{(A_1+b_1Q)+NP}{K}\right)-\frac{Q}{2N}(cH+(K-1)H_1) \qquad (5)$$

Maximization of Z can be achieved by minimizing the function

$$R(K)=\frac{D}{Q}\left[c(A+NP+bQ)+\frac{(A_1+b_1Q+NP)}{K}\right]+\frac{Q}{2N}(cH+(K-1)H_1) \qquad (6)$$

In the above equation, K is a positive integer. At a particular value of K, the value of $Q = Q^*(K)$ is obtained on equating the first derivative of 'R(K)' with respect to 'Q' equal to zero. Thus

$$Q^*(K)=\sqrt{\frac{2DN\left(c(A+NP)+\frac{(A_1+NP)}{K}\right)}{(cH+(K-1)H_1)}} \qquad (7)$$

On substituting Q = Q (K) in (6) the minimum value of R = R (K) is obtained. Thus,

$$R^*(K)=\sqrt{\frac{2D\left[c(A+NP)+\frac{(A_1+NP)}{K}\right][cH+(K-1)H_1]}{N}}+\left[cb+\frac{b_1}{K}\right]D \qquad (8)$$

On squaring and dividing both sides of equation (8) by 2ND, we get

$$T^*(K)=\frac{(R^*(K))^2}{2ND}=\left(c(A+NP+bQ)+\frac{(A_1+NP+b_1Q)}{K}\right)(cH+(K-I)H_1) \qquad (9)$$

$$= c^2H(A+bQ+NP) - c(A+bQ+NP)H_1+(A_1+b_1Q+NP)H_1 + cH_1\,K(A+bQ+NP)$$

$$+ (A_1+b_1Q+NP)\frac{(cH-H_1)}{K} \qquad (10)$$

In order to minimize T(K) we select $K = K_0$ such that,

$$T(K_0) \leq T(K_0+1) \qquad (11)$$

$$T(K_0) \geq T(K_0-1) \qquad (12)$$

Substituting the value in equation (11) we obtain

$$K_o(K_o-1) \leq (A_1+b_1Q+NP)\frac{(cH-H_1)}{K} \qquad (13)$$

$$K_o (K_o+1) \geq (A_1+b_1Q+NP)\frac{(cH-H_1)}{K} \quad (14)$$

Combining (13) and (14), we have

$$K_o (K_o-1) \leq (A_1+b_1Q+NP)\frac{(cH-H_1)}{K} \leq K_o (K_o+1) \quad (15)$$

If $cH < H_1$ the value of K_0 must be equal to 1. For extreme value of c = 0 the supplier perfectly dominates over the buyer and thus $K_0 = 1$. On the other hand when $c = \infty$, the buyer perfectly dominates over the supplier and the supplier determines his inventory policy as per the buyer's E.O.Q.

IV. Hypothetical Problem

D = 15000 units per year.
A = (a+ bQ + NP) = Rs. 15 per order (for the buyer).
H = Rs. 0.1 per item per year (for the buyer)
H_1 = Rs. 20 per order (for the supplier).
$A_1 = (a_1 + b_1Q + NP)$ = Rs. 20 per order (for the supplier)
N =4
a = b = 0.001 and $a_1 = b_1 = 0.004$.
Case 1: c = 1

$$\frac{A_1(cH-H_1)}{cAH_1} = -1.3267$$

Hence, $K_o = 1$
Buyer's order quantity

$$Q(K_o) = \sqrt{\frac{2ND(cA + A_1/K_o)}{(cH+(K_o-1)H_1)}} = \sqrt{\frac{2x4x15000\ (15+20)}{0.1}} = 6480.741 \approx 6481$$

Supplier's order quantity = $K_o.Q(K_o)$ = 1 x 6480.741 = 6480.741 = 6481. Compensation to be paid to the buyer $X(Q(K_o))$ = 24.6459 per year.

Case 2: c = 1.2

$$\frac{A_1(cH-H_1)}{cAH_1} = -1.1044$$

Hence $K_o = 1$
Buyer's order quantity $Q(K_o) = 6164$
Supplier's order quantity = $K_o.Q(K_o)$ = 1 x 6164 = 6164
Compensation to be paid to the buyer:

$X(Q(K_o))$ = Rs. 17.1459 per year

V. Conclusion

In this paper, the hypothetical problem shows that the supplier's order quantity and the buyer's order quantity are same. This in favour of the JIT approach, because the supplier supplies in necessary quantities as required by the buyer, thus having reduced inventories. As the value of 'c' is increased the order quantity is decreased and thus compensation to be paid to the buyer is decreased. Thus, the order quantity should be small leading to more compensation. The increased compensation costs induce the buyer to change his ordering policy. This is again same to JIT purchasing policy whose major aspect is receiving orders in small quantities but frequent deliveries.

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AUTHOR(S) PROFILE

Dr. Kavita Dave, received the M.Sc degree with Gold Medalist in Statistics from Gujarat University and Ph.D. She is Ph.D guide of GUJARAT UNIVERSITY, member of board of studies of BHAVNAGAR UNIVERSITY. She is associated with Gujarat Law Society as a faculty of Statistics. She is awarded Best Educationist Award for Excellence in Education by Indian Solitary Council, New Delhi.