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MATHEMATICAL MODEL FOR CALCULATING INVENTORY CARRYING COST

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ABSTRACT:

In inventory management, the Economic Order Quantity (E.O.Q.) plays a very important part as it determines the order quantity and hence the periodic number of orders as well. To calculate this EOQ, a variable is required which indicates the inventory carrying cost (I.C.C) as a percentage of the procurement cost. This percentage is generally taken to be 18%. However, in practice the I.C.C. consists of various variable and fixed cost components which vary from industry to industry and hence, I.C.C. cannot always be assumed to be 18% of Procurement Cost. The paper aims at deriving a formula for calculating the Inventory Carrying Cost by including all its cost components. This will help us in calculating the E.O.Q. more accurately and thus the total inventory cost can be reduced, drastically.

KEYWORDS:

Economic Order Quantity, Inventory Carrying Cost, Mathematical model

INTRODUCTION:

METHODOLOGY:

Components of the inventory carrying cost:[1]

The holding cost or the inventory carrying cost is generally assumed to be 18% of the average inventory cost. However, inventory holding cost consists of various components. These include:

- Capital investment in inventory
- Inventory insurance
- Capital invested in area of storage i.e. warehouse area
- Area insurance
- Salary of all workers working in stores
- Electricity expenses
- Cost of preparing purchase requisition
- Cost of creating purchase orders
- Cost of reviewing inventory level
- Costs involved in receiving and checking items as they are received from the vendor
- Costs incurred in preparing and processing the payments made to the vendor when the invoice is received
- Relocation costs
- Shrinkage costs
- Obsolescence costs

- Damage costs
- Packing and unpacking costs
- Transportation costs
- Annual maintenance costs

Although some of the costs are fixed costs, they may vary from industry to industry. Various factors like local taxes, variation of distance travelled, number of salaried employees, variation in electricity rates, fuel rates etc bring about the variation in the inventory carrying cost. Thus, inventory cost averaged to 18% of inventory value may not be accurate always. The changes in this value can bring about huge monetary differences. Hence, all the factors should be considered while calculating inventory holding cost and then calculating the EOQ.

For these costs the outputs required are:

Fixed components:

1) Salary of all workers
2) Electricity bill
3) Capital blocked for warehouse area or rent paid or interest on loan
4) Insurance paid for the storage space
5) Insurance paid for inventory
6) Internal transportation equipment cost
7) Storage equipment cost
8) Cost of maintenance and running cost of transportation equipment
9) Annual Maintenance Charges paid

Variable components:

10) Transportation cost

11) Shrinkage/relocation/obsolescence/damage/packing and unpacking/rejection costs

The inputs required for obtaining these outputs are:

1) Total monthly salary paid
2) Average monthly electricity bill
3) Interest rate per month on loan taken for purchasing the warehouse area
   Or
   Rent paid per month
   Or
   Capital blocked
4) Insurance premium paid per month for the area
5) Insurance premium paid per month for the inventory
6) A) Number of transportation equipment
   B) Initial cost
   C) Life of transportation equipment
7) A) Number of storage equipment
   B) Initial cost
   C) Life of storage equipment
8) A) Number of maintenance equipment
   B) Initial cost

C) Life of maintenance equipment

9) Annual Maintenance Charges

10) A) Number of transport vehicles used

B) Distance travelled vis-à-vis cost incurred

11) Shrinkage/relocation/obsolescence/damage/packing and unpacking/rejection costs

Derivation of formula:

Let,

s = total salary given to all employees working in inventory management per month

e = electricity bill per month

i = interest on loan taken per month

r = rent paid for the warehouse per month

c = capital blocked for the storage area per month

ip_a = insurance premium paid for the area of storage per month

ip_i = insurance premium paid for the inventory per month

ic_t = initial cost of transport equipment

l_t = life in months of transport equipment

ic_s = initial cost of storage equipment

l_s = life in months of storage equipment

t = total transportation cost

v = number of vehicles required for transportation

d = total distance travelled

ic_m = initial cost of maintenance equipment

l_m = life in months of maintenance equipment

A.M.C = annual maintenance cost

b = breakdown maintenance cost per month

Calculation of costs:

1) Fixed Cost (F):

$$F = s + e + (i \text{ or } r \text{ or } c) + ip_a + ip_i + ic_t/l_t + ic_s/l_s$$

2) Variable Cost (V):

- Transportation cost (t):

  $t \alpha v$

  $t \alpha d$

  Hence, $t = kvd$ where k is the proportionality constant

- Shrinkage, obsolescence, rejection cost (f)

$$V = t + f$$
$$= kvd + f$$

3) Maintenance Cost(M):
   - Fixed: A.M.C + ic_m/l_m
   - Variable: b

$$M = A.M.C. + ic_m/l_m + b$$

4) Total Inventory Carrying Cost (I):

$$I = F + V + M$$
$$= s + e + (i \text{ or } r \text{ or } c) + ip_a + ip_i + ic_t/l_t + ic_s/l_s + kvd + f + A.M.C. + ic_m/l_m + b$$

CASE STUDY:

The industry from which data is acquired manufactures automobile components and supplies them to an automobile manufacturing company. From the data acquired from this industry, using the above derived formula and considering all the components,

Inventory Carrying Cost is calculated in three parts-Fixed Cost, Variable Cost and Maintenance Cost

Fixed Costs = Rs 2,11,068

Variable Costs = Rs 43,436

Maintenance Costs = Rs 1,924

Total Inventory Carrying Cost (I.C.C.) = Fixed Costs + Variable Costs + Maintenance Costs

= Rs 2,56,248 (per month)

Procurement Cost (P.C.) as given by the industry = Rs 45,79,503 (per month)

1) **Calculating percentage of monthly procurement cost is the average monthly inventory holding cost:**

Inventory Carrying Cost percentage = Total Inventory Cost/Procurement Cost * 100

Therefore,

I.C.C. = 5.59% of P.C.

2) **Calculation of E.O.Q:**

EOQs using 18% I.C.C. and 5.59% I.C.C. are calculated as follows:

The formula used for this calculation will be:

E.O.Q.= q_0

$q_0 = \sqrt{((2 * S * C_p) / (C_u * i))}$[2]

where,

S = annual consumption

C_u = unit cost

C_p = procurement cost

i = average inventory percentage of procurement cost

In the calculations for the two cases, S, C_u, C_p will remain constant.

Let,

$q_{0\ (5.59)}$ = E.O.Q. when I.C.C. is 5.59% of P.C.

$q_{0\ (18)}$ = E.O.Q. when I.C.C. is 18% of P.C.

- When i = 0.059

$q_{0\,(5.59)} = \sqrt{((2 * S * C_p) / (C_u * .0559))}$

- When i = 0.18

$q_{0\,(18)} = \sqrt{((2 * S * C_p) / (C_u * .18))}$

$q_{0\,(5.59)} / q_{0\,(18)} = (\sqrt{((2 * S * C_p) / (C_u * .0559))}) / (\sqrt{((2 * S * C_p) / (C_u * .18))})$

$= \sqrt{(0.18/0.0559)}$

$= 1.79$

Therefore,

$$\mathbf{q_{0\,(5.59)} = 1.79 * q_{0\,(18)}}$$

3) Calculation of number of orders:

Number of orders = Annual consumption/ E.O.Q.

In our case, according to the data received,

Annual Consumption (S) = 86082

Let,

$n_{(5.59)}$ = Number of orders when i = 5.59%

$n_{(18)}$ = Number of orders when i = 18%

Thus,

$n_{(5.59)} = 86082 / q_{0\,(5.59)}$

$n_{(18)} = 86082 / q_{0\,(18)}$

Therefore,

$n_{(5.59)} / n_{(18)} = q_{0\,(18)} / q_{0\,(5.59)} = 1/1.79 = 0.56$

Therefore,

$$\mathbf{n_{(5.59)} = 0.56 * n_{(18)}}$$

CONCLUSION:

In any business venture, inventories play a vital role. . Inventory constitutes major parts, approximately 40% to 80% of gross working capital depending upon the nature and size of the industrial unit. If the inventories are not controlled effectively it will create many problems in the industry. So there is a need for every company to control its inventory in all stages. The basic inventory management aim is to optimize the inventory in relation to its cost involved. The total inventory costs consists of 2 components-

1) Procurement Cost
2) Inventory Holding Cost

In general, the inventory holding cost is approximated to 14-18% of the procurement cost. This percentage is considered in the formula to calculate Economic Order Quantity (EOQ). The Economic Order Quantity is the most vital as it decides the amount to be ordered and the duration after which an order is to be placed. The EOQ thus determines the ordering cost as well as the inventory carrying cost.

The inventory holding cost consists of various components such as inventory transportation costs, capital investments in area as well as the inventory, electricity charges, worker charges (salaries and overheads), insurance charges paid, rent paid etc. These factors are not considered holistically when the inventory cost is considered to be 18% of the procurement cost. These factors vary from industry to industry depending on the products, scale of the industry etc. Hence, this 18% is not accurate. The inventory cost thus can vary from 4-20% of the procurement cost. This is a wide range and hence cannot be averaged. If this percentage changes the EOQ calculations change. The variation in EOQ changes the number of orders placed. It brings about a drastic change in the procurement cost since the ordering cost varies as the numbers of orders vary. Also the quantity discounts can be availed since the order to be placed each time will be higher if the percentage is lower.

The formula derived above is a dynamic formula. It consists of various fixed as well as variable cost components which vary from industry to industry. All these components are explicitly included in the formula. Thus, for each industry the cost will change as per variables. Considering real costs will give an accurate estimate of the inventory carrying costs. This cost can also be calculated as various intervals during the year as per convenience i.e. monthly or after 2 months etc. If the costs vary during the year, the inventory costs will also vary. The EOQ and further ordering process will change according to different intervals. The dynamic nature of the formula will help in calculating the exact costs during the specified

period. The change in costs will directly affect the order quantity and this in turn will affect the total cost of inventory.

Thus, this formula mitigates the assumptions generally made in the EOQ models and prepares a dynamic model. This model thus helps in making accurate calculations and reducing the excessive inventory costs in certain industries.

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