INVENTORY CONTROL-II

(M.Sc. Sem-III)

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INTRODUCTION

In the previous chapter, we discussed the deterministic inventory problems based on the common assumption of constant and known demand for an item, as well as known lead time. When the demand or the lead time or both are not known with certainty and they need not be constant, then their random behavior needs to be described with a known probability distribution (discrete or continuous)

INVENTORY PROBLEMS WITH UNCERTAIN DEMAND

In many practical situations, it is observed that neither the consumption rate of material (commodity) is constant throughout the year nor is the lead time. To face these uncertainties in consumption rate and lead time, an extra stock is maintained to absorb the uncertainty in both the demand as well as lead time. This extra stock is termed as '*safety stock*', '*reserve stock*' or '*buffer stock*'. The reserve stock is maintained to take care of variation in demand during re-order period, while safety stock is maintained to take care of variation in lead time. Both reserve stock and safety stock are added to create a cushion to guard against risk of stock-outs and to provide better customer service.

The exact level of additional stock is based on the extent and nature of information available about the demand, lead time and stock-out cost. If demand remains constant and lead time is invariable, then there would be no fear of shortages and hence no need for additional stock. A fixed quantity would be re-ordered at fixed intervals called the *re-order level* (R.O.L.). Here, the fluctuations in demand have no importance, but level of demand during lead time is significant. In general, additional stock level is based on the following criteria :

(a) Probability of known and unknown shortages.
(b) Probability of delay in lead time.
(c) Maximum delay in lead time.
(d) Desired service level of customer service.

For an average demand during the average lead time, the additional stock is termed as *Buffer stock* (BS), *viz*,

$$\text{Buffer stock} = \text{Average demand} \times \text{Average lead time}$$

For example, suppose that for an item the monthly consumption is of 150 units, the normal and maximum lead times are 10 days and 30 days, respectively, then

$$\text{Buffer stock} = \frac{150}{30} \times \frac{(10+30)}{2} = 100 \text{ units}$$

When no stock-outs are desired,

Buffer stock = (Maximum demand during lead time) – (Average demand during lead time)

= max. (DDLT) – Average (DDLT).

When demand varies and lead time is constant, and an order for fixed quantity is ordered, the R.O.L. is set equal to the level of inventory required to satisfy the average demand during lead time plus buffer stock, i.e.,

$$R.O.L. = \text{Average } DDLT + BS$$

When demand rate varies about the average demand during a constant lead time (LT) period prediction of exact demand during lead time period becomes difficult, and therefore the re-order level is defined as :

$$\text{R.O.L.} = \text{Average (DDLT)} \times \text{LT}$$

However, this policy of setting re-order level results in stock-outs for about 50% time during lead time period. Thus, to avoid the chance of stock-out to occur, a buffer (*BS*) would be needed and re-order level is determined as follows :

$$\text{R.O.L.} = \text{Average (DDLT)} \times \text{LT} + \text{BS}$$

SAMPLE PROBLEMS

1. The monthly demand for an electronic machine is approximately 600 units. Every time as order is placed, a fixed cost of Rs. 800 is incurred. The daily holding cost per unit inventory is Re. 0.40. If the lead time is 10 days, determine EOQ and the number of order per month. In the past two months, the demand rate has gone as high as 50 units per day. For a re-ordering system based on inventory level, what should be the buffer stock? What should be the re-order level at this buffer stock? What should be the carrying cost?

Sol. We are given

D = 600 units per month, C_0=Rs. 80 per order, C_1=Re. 0.40 per unit per day, and LT = 10 days.

$$\therefore \quad EOQ(=Q^o) = \sqrt{\frac{2DC_0}{C_1}} = \sqrt{\frac{2 \times 600 \times 80}{0.40}} = 490 \text{ units}$$

$$\text{Number or orders } = \frac{D}{Q^o} = \frac{600}{490} = \text{ one order per month.}$$

$$\text{Average consumption } = \frac{600}{30} = 20 \text{ units per day.}$$

Since, maximum consumption is of 50 units per day,

$$\text{Buffer stock} = (50–20) \times \text{LT} = 30 \times 10 = 300 \text{ units}$$

$$\text{R.O.L.} = \text{Average } DDLT + \text{Buffer stock}$$

$$= 20 \times 10 + 300 = 500 \text{ units}$$

Average inventory level $= \text{Buffer stock} + \frac{1}{2}Q^{o}$

$$= 300 + \frac{1}{2} \times 490 = 545 \text{ units}$$

Thus, Inventory carrying cost per month = Rs. 545 × 0.40 = Rs. 218

2. A small camera maker sells imported electronic flash gun with his camera, as an optimal accessory. Last 3 month's records indicate that the average demand for the flash guns was about 100 units per month, the actual demand varying generally between 70 and 140 units per month. Only thrice had the demand exceeded 140 and was 150, 160 and 180 per month. The camera maker, by agreement with a reliable overseas suppliers, receives 100 guns each month. Calculate the most economic buffer stock the supplier should hold. Assume inventory carrying charges of 20% and thus limited cost of gun as Rs. 200 per unit. In case of excess demand, camera maker purchases extra units from other importers at a premium of Rs. 50 per unit.

Sol. We are given

D = 100 units per month, C_1= Rs. 200×0.20, and C_2 (cost of shortage) = Rs. 50 per unit.

Let the camera-man decide to keep a buffer stock of 75 units. Then,

$$\text{Average inventory level} = \text{Buffer stock} + \frac{1}{2}Q$$

$$= 75 + \frac{1}{2} \times 100 = 125 \text{ units.}$$

Total average cost for 3 months = Rs. (125×200×0.20) × 3 = Rs. 15,000.

It is, now obvious that with a starting stock of 175 units, only once in 3 months would there be a shortage (stock-out) of 5 units (when consumption rate is 180 units per month) and the same is purchased at premium of Rs. 50 each.

∴ Stock-out cost = 5 × Rs. 50 = Rs. 250.

Total inventory cost = Carrying cost + Stock-out cost

= Rs. 15,000 + Rs. 250 = Rs. 15,250.

The total inventory cost for 3 months for different levels of buffer stock is computed below :

Buffer stock (units)	*Maximum stock (BS + Q)*	*Inventory carrying cost (Rs.)*	*Stock-out cost (Rs.)*	*Total inventory cost (Rs.)*
75	175	15,000	250	15,250
65	165	13,800	750	14,550
60	160	13,200	1,000	14,200
50	150	12,000	1,500	13,500

From the above calculations, we observe that the minimum total inventory cost for 3 months is Rs. 13,500 and the corresponding most economic (optimum) buffer stock is around 50 units.

Remark : When the buffer stock maintained is very low, the inventory holding cost would be low but the shortages will occur very frequently and the cost of shortages would be very high. As against this if the buffer stock maintained is rather large, shortages would be rather rare, resulting into low shortage costs but the inventory costs would be high. Hence, it becomes necessary to strike balance between the cost of shortages and cost of inventory holding to arrive at an optimum buffer stock termed as reserve stock.

PROBLEMS

3. In certain food grains store, it takes about 7 days to get stock after placing the order, whereas daily 750 tones of wheat are dispatched by the store to neighboring markets. On ad-hoc basis, safety stock is assumed to be 20 day's stock. Calculate the re-order point.
4. The daily demand for an electronic machine is approximately 25 items. Every time an order is placed, a fixed cost of Rs. 25 is incurred. The daily holding cost per unit inventory is Re. 0.40. If the lead time is 16 days, determine the economic lot size and the re-order point.
5. In an inventory model, suppose that the shortages are not allowed and the production rate is infinite and R = 600 units per years, I = 0.20, C_0 = Rs. 80, P = Rs. 3, and lead time is 1 years.

(i) Find the optimal order quantity, (ii) Re-order point, (iii) Minimum average yearly cost.

6. A company uses 10,000 units per year of an item. The purchase price is Re. 1 per item. Ordering cost is Rs. 25 per order. Carrying cost per year is 12% of the inventory value.

   (i) Find the *EOQ*.

   (ii) Find the number of orders/year.

   (iii) If the lead time is 4 weeks and assuming. 50 working weeks per year, find there-order point.

7. Following information in an inventory problem is available :

Annual demand	= 2,400 units	Unit price	= Rs. 2.40
Ordering cost	= Rs. 4.00	Storage cost	= 2% per year
Interest rate	= 10% per annum	Lead time	= ½ month

Calculate : *EOQ,* Re-order level and total annual inventory cost.

How much does the total annual cost vary if the unit price is changed to Rs. 5?

8. Obtain (i) Economic order quantity, (ii) Number of orders, (iii) Re-order level, and (iv) Safety stock, for the following inventory problem :

Annual demand	= 36,000 units	Cost per unit	= Re. 1
Ordering cost	= Rs. 25	Cost of capital	= 15%
Store charges	= 5%	Leadtime	= ½ month

Safety stock = one month's consumptions.

9. The following relations to inventory costs have been established for *ABC* ltd :

(i) Orders must be placed in multiples of 100 units.

(ii) Requirement for the year are 3,00,000 units.

(iii) The purchase price per unit is Rs. 3.

(iv) Carrying cost is 25 per cent of the purchase price of goods.

(v) Cost per order placed is Rs. 20.

(vi) Desired safety stock is 10,000 units. This amount is on hand initially.

(vii) Three days are required for delivery.

Calculate : (i) *EOQ,* (ii) How many orders should the company place each year? And (iii) At what inventory level should an order be placed?

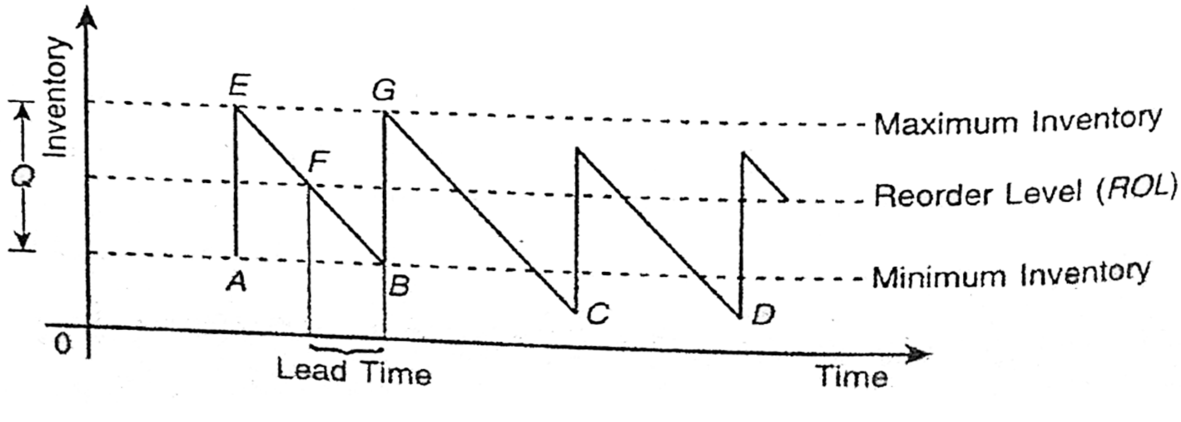
10. Given the following data relating to one of the *A* class items, what inventory model do you suggest? What would be *EOQ*, *ROL* and the average inventory under the suggested model? Annual demand = 1,000 units. Cost per item = Rs. 25. Order cost per order = Rs. 20, and Holding cost = 40%. Past lead times (days) are 10, 8, 12, 13 and 7.

3. SYSYTEMS OF INVENTORY CONTROL

Basically, there are two types of inventory control systems, although both have numerous variations. One is known as "*Fixed order quantity system*" (*Q*-system) and the other "*Fixed order interval system*" (or Periodic review system or *P*-system).

Fixed Order Quantity System (Q-system)

This is also known as *Two-bin System* or *Maximum-minimum System.* In this system, a re-order is made when the stocks fall to a 're-order level' which is equal to the lead time requirements plus buffer stocks. In the two-bin system, the review period is always fixed. Further, the *bin* of an item is of two types, namely the *main-bin* and *reserve-bin*. From main-bin we meet the demand that occurs before lead time and from the reserve-bin we meet the demand during lead time. When the main-bin is empty, a fresh order is placed which should arrive well before the reserve-bin is exhausted. The procurement and consumption cycle is shown in figure.



In Figure, it is shown that a supply equal to EOQ is received at point A and the quantity in stock reaches a point E. The materials are then issued and at time F, when the stock reaches the R.O.L., an order is placed for quantity Q = EOQ and the issues continued. At point B the supplies of order placed at point F are received and the stock (inventory) reaches G. At point C there is a delay in receiving the supplies and we cut into the buffer stock. Thus, for this system of ordering, we fix up the size of the order, i.e., every time same quantity 'Q' is order but the time of placing the order is allowed to vary depending upon the actual usage or demand.

The procedure for determining an optimum solution is as under :

Step-1 : Compute Q^o based on the assumptions of the fundamental problem of *EOQ*, i.e., $Q^o = \sqrt{2DC_0 / C_1}$.

Step-2 : Determine R.O.L. so as to trade-off between stock-out (shortage) cost and carrying cost for the reserve stock.

The reserve stock is the number of units by which R.O.L. is increased above the average demand during lead time (DDLT) to balance the shortage cost. However, if DDLT as well as lead time are normally distributed, then

R.O.L. = Average DDLT + Reserve stock + Safety stock.

Where, Reserve stock = Standard deviation of DDLT × Service level factor,

And Safety stock = Average demand during maximum delay in lead time × Probability of delay

The fixed order quantity system is also known by other names such as '*perpetual inventory system'* or '*re-order point inventory system*' or '(*Q, R*) system'.