Different Inventory Management Model

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I. INVENTORY

Inventory is the most important asset of the organization. It consists of more than 50% of the total working capital. Inventory consists of raw materials, work-in-process and completely finished goods which are company's current asset that are ready or will be ready for sale. Inventory is one of the most important assets as it is the main source of revenue generation.

In other words it is the value of the goods & raw materials held by a firm to support the production process or for service activities like repair or maintenance or for sale to the ultimate consumer.

Definitions Accounting Standard (AS) 2

The following terms are used in this Standard with the meanings specified:

Inventories are assets:

1) held for sale in the ordinary course of business;
2) in the process of production for such sale; or
3) in the form of materials or supplies to be consumed in the production process or in the rendering of services.

Net realizable value is the estimated selling price in the ordinary course of business less the estimated costs of completion and the estimated costs necessary to make the sale.

Inventories encompass goods purchased and held for resale.

Measurement of Inventories

Inventories should be valued at the lower of cost and net realizable value.

(http://www.mca.gov.in/Ministry/notification)

Reasons for keeping stock

1. Time - The time lags from supplier to user at every stage of production & distribution, requires the firm to keep certain amounts of stock to use in this lead time.
2. Seasonal Demand: demands changes with time, i.e. seasonal demand but production is done before hand. This lead to stock accumulation, consider for example how umbrellas used only in rainy season are produced months before consumption. This leads to stock accumulation.
3. Uncertainty – Stocks are kept as buffers to meet uncertainties in demand, supply and distribution of goods.
4. Economies of scale - Bulk buying, movement and storing brings in saving in the form of economies of scale, thus inventory storage helps in reduction of cost.
5. Appreciation in Value - In some cases, some stock gains the required value when it is kept over the time to allow it reach the desired standard for consumption, or for production. For example; wine in the winery industry.

(https://en.wikipedia.org/wiki/Inventory_theory)

Before discussing about Inventory management models, one need to see what the different inventory management tools are all about are

Inventory Management Tool is of 4 Categories

Four categories are as given below

- hardware,
- software,
- management models, and
- audit systems.

It is the work of the manager to see that all the four tools are properly synchronized & integrated. This enables the system to work properly. Sometimes the manager requires to be a change agent, bringing a new inventory management tool in an organization. The manager needs to evaluate the tools periodically and adopt the one which maximizes the profit.

Software

Inventory Management control software is the backbone of inventory management in any of the organization. The software maintains the systematic record of inventory transactions, quantity, resupply orders and product location.

Some small organizations use a spreadsheet as their main inventory management tool. Whereas large organization uses databases with a menu driven user interface. Some firms use off the shelf software, whereas others develop it internally. The reason being different business model has different solutions.

Hardware

Desktops, servers, dumb terminals, asset tags, RF devices, scannable bar code label printer, RFID tags and Point of Sale devices are some of the examples of hardware inventory

management tool. Software cannot give result without the hardware. Software reguires input devices to control the inventory.

The art of inventory management depends upon the right selection of tools to balance infrastructure versus labor

Audit Systems

Audit is nothing but regular check or review to see that material, people and process are in line with the firm's strategic goals.

Audit systems measure the firms success rate. The auditors conduct the audit of inventory annually to see that the valuation stated of the inventory asset is reasonable.

Some of the inventory audit procedures that the auditors use are as follows:

Cutoff analysis, Observe the physical inventory count, Reconcile the inventory count to the general ledger, Test high-value items, Test error-prone items, Test inventory in transit, Test for lower of cost or market, Inventory allowances etc.

Each of these 4 categories of tools represents the legs that support the inventory management. A proper blend of these tools can take the organization to the next level. (www.purchasing and procurement center.com Inventory management tool; www.gigatrak.com/inventory-tools/)

II. INVENTORY MANAGEMENT MODELS

From independent to dependent demand to the specific science of calculating safety stock, the models available to the logistics community are critical tools of inventory control. Whether it is an upper level model of the entire system or the local tactics on how to execute periodic reviews, having a framework is critical to inventory success.

Though inventory serves an important and essential role, in the supply & demand of products, the expense associated with Maintaining and financing inventories is a major part of the cost of doing business. In large firms, the cost associated with stock can run into the billions of dollars.

Two important questions that must be answered in order to effectively manage inventories are as follows:

1. How much should be ordered when the stock for an item is over or when to restock depleted items?
2. When should the inventory be restocked?

The purpose of this topic is to show how quantitative models can assist in making these decisions

We will first see deterministic inventory models in which it is assumed that the demand growth for the product is constant or nearly constant. Next we will see probabilistic inventory models in which the demand for the product fluctuates and can be understood only in probabilistic terms.

Inventory models are based on some distinguished assumptions. Some examples of assumptions may include the following:

- The lead time can be fixed or can be of random length and is constant
- All excess demand is back-ordered and all excess demand is lost
- All stock levels are periodically reviewed i.e. once a week or once a year etc.
- Demand is known and constant
- There is only carrying and holding cost as variable cost
- If inventory order is placed at the right time then stock out and shortages can be avoided.

Quantity discounts are not possible. (Optimization and Operations Research – Vol. IV - Inventory Models - Waldmann K.-H www.eolss.net/sample-chapters/c02/e6; 2013 Pearson Education, Inc. publishing as Prentice Hall chapter 12 Inventory control models)

Economic Order Quantity (EDQ) Model

The economic order quantity (EOQ) model is applicable when the demand for a product has a constant, or nearly constant. The constant demand rate assumption means that the same number of units is taken from stock each period of time for e.g. 25 units every day, 100 units every month, and so on.

To explain the EOQ model, let us take an example of Pepsi Company which is a distributor of soft drinks & fruit juice product. The main warehouse is located in Mumbai, Delhi, Kolkata, & Chennai, Pepsi supplies nearly to 100,000 retail stores with beverage products. The soft drink inventory, which constitutes about 80% of the company's total inventory, averages approximately 500,000 cases. With an average cost per case of approximately Rs. 8, Pepsi estimates the value of its soft drink inventory to be Rs. 40, 00,000.

The logistic manager has decided to do a detailed study of the inventory costs associated with Pepsi, the number-one-selling soft drink. The purpose of the study is to establish the how-much-to-order and the when-to-order decisions for pepsi that will give the lowest possible total cost. As the first step in the study, the logistic manager has obtained the following demand data for the past 10 weeks:

Week	Demand(cases)
1	2,000
2	2,025
3	1,950
4	2,050
5	2,050
6	2,050
7	2,000
8	1,915
9	1,960
10	2,000
Total cases	20,000
Average cases per week	2,000

In the above data, the demand figures do not show a constant demand rate. However, given the relatively low variability exhibited by the weekly demand, inventory planning with a constant demand rate of 2000 cases per week appears acceptable. In reality, we will find that the actual inventory situation ever seldom, if ever, satisfies the assumptions of the model exactly. Thus, in any situation, the manager must see whether the model assumptions are close enough to reality for the model to be useful. In this case, since demand varies from a low of 1915 cases to a high of 2050 cases, the assumption of constant demand of 2000 cases per week appears to be approximately reasonable.

The how-much-to order decision depends upon the following criteria which involves selecting an order quantity that draws a compromise between (1) keeping small inventories and ordering regularly and (2) keeping large inventories and ordering occasionally. The first alternative can result in undesirably high ordering costs, while the second alternative can result in undesirably high inventory holding costs. To find an optimal solution between these conflicting choices, let us see a mathematical model that will show the total cost as the sum of the holding cost and the ordering cost.

Holding costs are the costs associated with carrying or maintaining a given level of stock; these costs depend on the size of the inventory. First, of all there is the cost of financing the inventory i.e. investment in the inventory. When an organization borrows money, it has to pay an interest charge; if the firm uses its own money for other investments. In either case, an interest cost is there for the fund tied up in inventory. This cost of capital is usually expressed as a percentage of the amount invested. Pepsi company estimates its cost of capital at an annual rate of 15%.

There are a number of other holding costs, such as taxes, insurance, pilferage, breakage, and warehouse overhead that also depend on the value of the inventory. Pepsi estimates these other costs at an annual rate of approximately 7% of the value of its inventory. Thus, the total holding cost for the Pepsi company inventory is 22% of the value of the inventory.

Assume that the cost of one case of Pepsi soft drink is Rs.10. Since Pepsi estimates its annual holding cost to be 22% of the value of its inventory, the cost of holding one case of Pepsi in inventory for 1 year is 0.22 (Rs. 10) =Rs.2.20.

Next we need to analyze, is to determine the **ordering cost**. This cost is fixed in nature regardless of the order quantity; it covers the preparation of the voucher, the processing of the order including payment, invoice verification, transportation, telephone, receiving, postage and so on. For Pepsi Company, the largest portion of the ordering cost involves the salaries of the purchasers. An analysis of the purchasing process showed that a purchaser spends approximately 45 minutes preparing and processing an order for Pepsi. With a wage rate and fringe benefit cost for purchasers of Rs.25 per hour, the labor portion of the ordering cost is Rs.20. Making allowances for postage, paper, telephone, transportation, and receiving costs at Rs. 10 per order, the manager estimates that the ordering cost is Rs. 55 per order. That is, Pepsi Company is paying Rs. 55 per order regardless of the quantity requested in the order.

The demand information, holding cost & ordering cost are the three important information needed to work out the EOQ model. So we need to find out the value of Q that will minimize the holding & ordering cost.

Q = how much to order

$$Q^* = \sqrt{\frac{2DC_0}{C_h}}$$

Q*EOQ

D= Annual demand

Co=Ordering cost per order

Ch= Holding cost per unit for a year

$$Q^* = \sqrt{\frac{2(104{,}000)55}{2.20}} = 2280 \text{ cases}$$

Economic order quantity is 2280 cases per week which will have the lowest total annual holding cost & ordering cost.

Let us see what is the annual cost for 2280 cases

Total Annual cost ⟷ Total ordering cost + Total Holding cost

The total annual cost model is

$$TC = \frac{1}{2}QC_h + \frac{D}{Q}C_0$$

TC= Total cost

Q= Quantity to be ordered

Ch= holding cost

Co= ordering cost

D= annual demand

$$TC = \frac{1}{2}Q(\$2.20) + \frac{104{,}000}{Q}(\$55) = 1.1Q + \frac{5720{,}000}{Q}$$

So TC is **5016.77** for 2280 cases. This is the lowest cost for Q=2280

We can prove this with the table with different quantities & total cost.

Demand/order Quantity	Annual Cost		
	Holding	Ordering	Total
5000	$5500	$1144	$6644
4000	4400	1430	5830

3000	3300	1906	5260
2000	2200	2860	5060
1000	1100	5720	6820

(2013 Pearson Education, Inc. publishing as Prentice Hall chapter 12 Inventory control models; kczx.whu.edu.cn/G2S/Utility/download2 Chapter 7 Inventory model; Cost Accounting Charles T. Horngren and Srikant M. Datar chapter 20 thirteen edition)

Sensitivity of the EOQ Formula

The EOQ assumes that all data are known with certaintiy. If the input values changes then what will be the effect on the formulae i.e. what will be the optimal value of Q.

So the magnitude and effect of the changes on Q is called sensitivity analysis. This type of analysis is necessary in practical life because the values of the inputs for EOQ is usually estimated and hence are subject to change or error.

Determining When to Order: Reorder Point

After we have decided how much quantity to order, we shall see now when to order. In simple cases it is assumed that a company will place order when the inventory for particular items becomes zero and gets the stock immediately but this is not true or practical.

The time between receipt & placing of an order called the lead time or delivery time is often few weeks or few days. Thus Reoreder level is the inventory level at which an order should be placed

ROP formula = Demand per day X Lead time, in days

Lead time is the time required to receive an order

(kczx.whu.edu.cn/G2S/Utility/download2 Chapter 7 Inventory model)

Reorder level = demand during lead time = lead time x demand per unit time

ROL = LT x D

Reorder Level with Longer Lead Time

When lead time is longer than the stock cycle. There is always one order outstanding.

Example:

When it is time to place order B, there is one order, A outstanding and due to arrive before B.

The stock on hand plus the outstanding order must be enough to last until B arrive or equal the lead time demand

ROL = Stock on hand+ Stock on order =LT x D

ROL= (LT x D) - Stock on order

(http://e-learning.tu.ac.th/IM322/doc_download/IM322_2_121250.pdf)

Economic Production Lot Size Model

In this model there is constant supply of units to inventory at a constant rate over several weeks or over several days.

It assumes that same number of units is supplied to inventory each period of time for e.g. 20 units every day or 80 units every week. This model is good for firms in which, once order is placed, production starts and a constant no. of units is added to stock every day until production run has been completed

This model is suitable for the firms where production rate is greater than the demand rate. This means that each day we will be producing greater units than the demand in each production run.

For example, if the constant demand rate is 4000units per week, the production rate must be at least 4000 units per week to meet the demand

During the production run, production will be adding to the inventory whereas demand will be reducing the inventory. Since it is assumed that production rate is more than the demand rate, each day we will be producing more units than the demand. So excess production will gradually increase the inventory .When production run is finished, the demand will cause the inventory level to decline until new production run is started. (kczx.whu.edu.cn/G2S/Utility/download2 Chapter 7 Inventory model)

An Inventory Model with Planned Shortages

In many cases shortages are undesirable and should be avoided as far as possible. However there other cases where shortages are desirable. This can be seen when holding cost of the item is very high and also the value of inventory per unit. For example a car dealers inventory where the cost of each car is very high and also the holding cost. This model is suitable when the customer is ready or willing to wait few weeks or days, till the stock arrives

This type of shortage is called a backorder In a backorder, we assume that the customer is ready to wait for the new shipment to arrive as the supplier is out of stock and then the order is filled. In backorder the waiting time is usually short. This can be explained with an illustration.

If 100 cars backorders exist when a new shipment of 150 cars arrive, the 100 cars backorder are shipped to the customers and the remaining 50 cars are placed in inventory. Thus 50 is the maximum inventory level. The inventory cycle of T days is divided into 2 parts i.e. part 1 is when stock is on hand and orders are taken as they come and part 2 when there is stock outs and all remaining order is put on backorder.

Quantity Discounts for the EOQ Model.

In this model we will discuss the situations when suppliers give huge discounts if the goods are ordered in large quantity.

These discounts help the firm to reduce its cost by getting good discounts on large orders. We will see how the EOQ model can be used when quantity discount are available.

Let us take an example of a product where EOQ is applicable and the supplier has given the following discount table.

Discount section	Order quantity	Discount (%)	Unit Cost
1	0 to 1000	0	$50.00
2	1001 to 3000	10	45.00
3	3001 and over	25	37.50

The 25% discount looks very tempting but we need to order 3001 units is minimum order size, however more order quantities will also have higher holding cost. Thus we need to analyze the cost before making any decision.

Suppose the annual holding cost are 40%, and ordering cost of 60 $ per order and the annual demand is 5000 units; what should be the order quantity in this situation.

In the EOQ model, purchase cost of the stock or item was not included because the cost was constant and not affected by the ordering policy decision. But in the qty discount model, the purchase cost depends on the quantity ordered.

$$Q_1^* = \sqrt{\frac{2(5000)60}{(0.40)(50.00)}} = 173$$

Discount Category	Unit Cost	Order Quantity	Annual cost			
			Holding	Ordering	Purchase	Total
1	$50.00	173	$1730	$1416	$250,000	$253,146
2	45.00	1000	9000	300	45,000	54,300
3	37.50	3000	22,500	100	187,500	210,100

$$TC = \frac{Q}{2}C_h + \frac{D}{Q}C_0 + DC$$

From the above table we can see that the minimum cost is to order 1000 units at 10% discount rate.

(kczx.whu.edu.cn/G2S/Utility/download2 Chapter 7 Inventory model; 2013 Pearson Education, Inc. publishing as Prentice Hall chapter 12 Inventory control models)

A Single-Period Inventory Model with Probabilistic Demand

Some times the demand rate is not deterministic. So models are developed where demand is treated as probability distribution.

In this we are taking single period inventory model with demand probability.In this model it is assumed that the product is either sold out, or there is surplus of items not sold at the end of the period that will be sold as a salvage value.

The single period inventory model is for seasonal or perishable items that cannot be sold in the future or kept in stock. In this case the buyer places an order for each item and then either there is stock out or there is clearance sale of the surplus stock at the end of the season.

No items are carried in inventory and sold the following year.

If the demand were known in advance for a single period inventory situation, then there would have been no problem. But in most cases the exact quantity of demand is not known. Thus we require the probabilities associated with the different demand values

So a single-period model is based on probabilistic demand.

(kczx.whu.edu.cn/G2S/Utility/download2 Chapter 7 Inventory model)

An Order-Quantity, Reorder-Point Model with Probabilistic Demand

In this model the inventory system works with many repeating cycles. This can be carried from one period to the next. When the inventory reaches the reorder level , the order for units is placed. Now here the demand is probabilistic so the time the time between the orders , or when the reorder will reach is not known and the time when order will arrive in inventory is also not known in advance.

The reorder point, the order quantity with probabilistic demand will look like the figure given below.

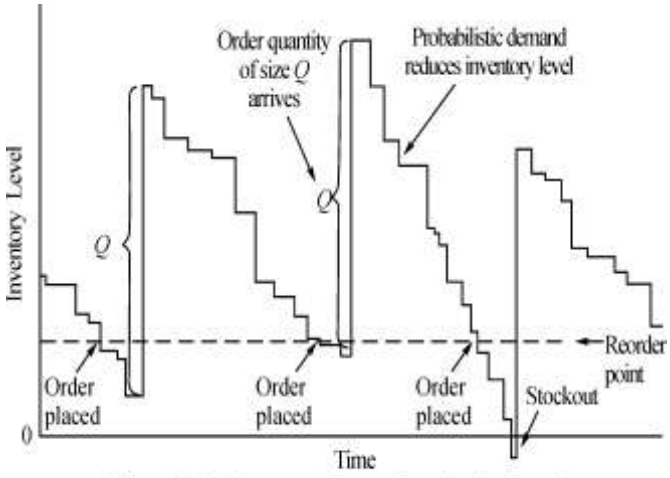

Figure 11.10 Inventory Pattern for an Order-Quantity, Reorder-Point Model with Probabilistic Demand

There is jump or increase in the inventory level whenever the order Q arrives. A new order is place when the order reaches reorder level. Many times the order arrives before the inventory level reaches zero. However at times when the demand is too high then there will be stock out before the order arrives.

It is very difficult to have a exact mathematical formulation of reorder-point, an order-quantity inventory model with probabilistic demand.

Let us see an example of Reni Ltd. Reni purchases a high intensity LED light for industrial lighting system from a good LED manufacturer. The Ordering cost is $ 12 per order, one LED cost $ 6 and has 20% annual holding cost which is 0.20 x $6=1.2. Reni has more than 1000 different customers, i.e. it has probabilistic demand. In fact the number of units demanded varies from week to week and day to day. The lead time for new order is 1 week. The old data says that by a normal probability distribution with average of 154 LED and a std deviation of 25 LED during a 1 week lead time. Thus the expected annual demand is 154 x 52weeks =8008 units per year. (kczx.whu.edu.cn/G2S/Utility/download2 Chapter 7 Inventory model)

The How-Much-to-Order Decision

We know the expected annual demand i.e. 8008 units. By applying EQO model we can know approximately the best order quantity

$$Q^* = \sqrt{\frac{2DC_0}{C_h}} = \sqrt{\frac{2(8008)()12}{(1.20)}} = 400 \text{ Unit}$$

Reni can order 20 orders per year with 12.5 working days between the orders (kczx.whu.edu.cn/G2S/Utility/download2 Chapter 7 Inventory model)

III. SUMMARY

The main motive of all the inventory models are the same i.e. How to order and when to order and also how much to order. The Basic EQO is based on some assumptions. If all these assumptions are valid then the EQO inventory model gives optimal answers. Whatever model is chosen the primary need is to lower the cost of holding and the cost of carrying the inventory. Different model is used depending on the situation and the nature of the product and the demand accuracy.

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