Statistics

Inventory Models

<u>1. Introduction</u>

By the end of this session, you will be able to:

- Explain the meaning of inventory control
- Explain the forms and functional role of inventory

Let us start with an introduction:

The word 'inventory' refers to any kind of resource that has economic value and is maintained to fulfill the present and future needs of an organization. Fred Hansman defined inventory as, an idle resource of any kind provided such a resource has economic value.

Such resources may be classified into three categories, **One**, physical resources such as raw materials, semi-finished goods, finished goods, spare parts, lubricants, etc., **Two**, human resources such as unused labour (manpower), and **Three**, financial resources such as working capital, etc.

Since the final product or output of a service organization such as bank, hospital, etc., cannot be stored for use in the future, the concept of inventory control then is associated with the various forms of productive capacity. The following are a few examples of the type of inventory held by various organizations.

Types of inventory held by manufacturers are Raw-materials, semi- finished goods, finished goods, spare parts, etc.

Hospital will carry Number of beds, stock of drugs, specialized personnel, etc.

Banks will carry the Cash reserves, tellers, etc and

Airline company will carry Seating capacity, spare parts, specialized maintenance crew, etc.

Inventory of resources is held to provide desirable service to customers or users and to achieve sales turnover target investment in large inventories adversely affect an organizations cash flow and working capital as investment in inventory represents substantial portion of the total capital investment in any business.

It is therefore, essential to balance the advantage of having inventory of resources and the cost of maintaining it so as to determine an optimal level of inventory of each resource. This would ensure the total inventory cost is minimum.

<u>2. Inventory Control</u>

Inventory control system appears complicated however; there are only a few basic questions that need to be answered for an efficient control of inventory. Thus the most important of these are, What item should be stocked?, When should an order be placed to replenish inventory? And how much should be ordered in each replenishment.

What item should be stocked:

Since physical storage of inventory items is expensive control is needed to ensure that inventory level remains as low as possible. This implies that:

- Inventory level of existing items is kept at reasonable level
- Unnecessary items are not added to the inventory
- Items which have not been used for long time are removed from the inventory

The decision regarding physical storage of items needs an efficient inventory policy to develop trade-off between holding cost and demand of items. That is, comparison should be made between costs and benefits of holding an item in stock. Regular audit is required on the usage of items already in stock and to discontinue stocking of certain items if it is cheaper.

When should an order be placed to replenish inventory:

There are three different approaches to check the status of inventory.

- **1.** Periodic review system
- **2.** Fixed order quantity system
- **3.** Optional replenishments system

Periodic review system in which the orders are placed at regular intervals of time. The quantity ordered varies depending on the inventory in hand and in order at the time of review. This system is often used in situations where the level of inventory is reviewed at the end of fixed intervals of time and units consumed are replenished.

Fixed order quantity system is one in which the level of inventory is monitored regularly and when it drops to a specified level, a replenishment order for a fixed quantity is placed. Variation in demand is allowed by changing the time between orders.

Optional replenishments system combines a periodic review system with a minimum order quantity restriction. If calculated order quantity is less than the minimum forecasted value, no order is placed. This avoids the placement of small orders.

How much should be ordered in each replenishment: Every time an order is placed there are certain costs incurred on account of administration, transportation, inspection, etc. If large and frequent orders are placed, it increases the level of inventory.

Consequently the average inventory value then becomes high. If small and frequent orders are placed, it increases the cost of ordering and delivery but the average stock level becomes low. Thus the objective to determine optimal inventory is minimize the total inventory cost.

The order quantity usually depends on:

- Demand pattern
- Price of an item, discount options, total budget and warehouse space, etc
- Lead time

3. Functional Role of Inventory

Since investment in inventory represents a substantial portion of the total capital investment in any business. Therefore, questions like, why invest funds in inventory? And what benefits can be derived by involving inventories? Are frequently raised. Hence certain distinct forms of inventories are discussed below:

Lot size (Cycle) inventory:

It is the inventory necessary to meet the average demand during the successive replenishments.

The amount of such inventory depends upon the production lot size, economical shipment quantities, warehouse space available, replenishment lead time, price-quantity discount schedules and inventory carrying cost, etc.

Pipeline (Transit) inventory:

Since the movement of item cannot be instantaneous, optimal inventory level is required for shipment of inventory items to distribution centres and customers from production centers. Such an inventory is called a process inventory. This is because as it consists of materials actually being worked on or moving between work centers. Hence for satisfying demand without delay, it is essential to keep extra stock of inventory items at various work places to meet the demand while the supply is in transit. The amounts of pipeline inventory depend on the time required for shipment and the nature of demand.

Safety (Buffer) Inventory:

It is the specific level of extra stock of inventory that is maintained for protection against uncertainties of demand and the lead time necessary for delivery of goods.

Despite the principle of just in time as well as expected customer service needs, the demand and lead time both, in general are random variables with known probability distribution. Thus to avoid unpredictable shortage with a high penalty cost, additional stock of inventory item is maintained in addition to the regular stock.

The level of additional stock is determined by desirable trade-off between protection against demand and supply uncertainties and the level of investment in additional stock. Such additional stock is known as buffer stock as it provides buffer or safety margin against future uncertainty.

Seasonal inventory:

Inventory is also needed for items whose sales depends on seasonal pattern of demand and whose production or supply is not uniform, that is it varies with time. These include fashion items, agriculture products, children's toys, calendars, etc.

In these cases the manufacturer faces peak demand where the production facility is unable to meet the demand on a period by period basis.

Thus seasonal or anticipated inventories are built up in advance or are produced during the period of low demand provided items are not perishable to be used during the peak demand period. If items are to be produced, then to reduce the strain of peak demand periods upon production facilities, the production of such items may be continued during the low demand period.

However the amount of inventories to be either procured or produced to meet unexpected demand should be determined by balancing the holding or carrying and shortage (if any) costs of seasonal inventories.

Decoupling inventory:

If various manufacturing process or stages operate successively, then in the case of the breakdown of one or two due to any disturbance at some stage, the entire system could be affected. This kind of interdependence is not only costly but also disruptive for the entire system.

Thus stocking points of inventory are created between adjacent stages of production to achieve a certain degree of interdependence among stages of production. The decoupling inventories may be classified into four groups: Raw-material, Work-in-process inventory, finished goods inventory and spare parts inventory.

Raw Materials and Component parts: The bulk part of physical storage in terms of volume and value is of raw materials because it is processed to finished products. Thus, the raw material inventory is used to decouple the producer from the supplier.

This means, raw material and component parts inventory could

- Act as a buffer to take care of delays on the part of supplier and
- Guard against seasonal variations in the demand of final product

Work-in-process inventory: Since it takes time to convert raw material into finished product, work-inprocess inventory is incurred. This may be due to unbalanced loading of machines holdups, shortages of tools, etc.

This inventory takes the form of orders waiting to be transported between machines or of orders waiting to be processed on a particular machine. The level of such inventory can be changed by changing the manufacturing process, lot sizes or production schedules.

Finished goods inventory:

This is the inventory of final products that could be released for sale to the customers. The size of this inventory depends upon the demand, and the ability of the firm to sell its products, firm's ability to meet customer demand and shelf life of the product and storage capacity.

Spare parts inventory:

These are the parts that are used in the production process but do not become part of the product. The size of the inventory depends on the average life of the components.

4. Reasons & Factors Involved in Carrying Inventory

Following are the Reasons for carrying Inventory:

Inventory has been viewed as a necessary evil (Non- earning asset) that cannot be eliminated. It is termed as evil because maintaining inventory ties up money that could otherwise have been used for alternative purposes.

It also increases carrying cost.

However, it is considered a necessary investment to achieve workable system of production, distribution, and marketing of physical goods. Some of the important reasons for carrying inventory are as follows: improve customer service, reduce costs, maintenance of operational capability, irregular supply and demand, quantity discount and avoiding stock outs or shortages.

Improve customer service:

An inventory policy cannot be designed to respond to customers request for products or services in an instantaneous manner. It provides a desirable level of product or service to the customers (individuals and organizations). An optimal level of inventory maintains the sale as well as increases it to a certain extent.

Reduce costs:

Inventory holding or carrying costs are the expenses that are incurred during the storage of items. However, carrying items in warehouse can indirectly reduce operating costs in other activities and may actually bring in more revenue than carrying cost.

Holding inventories may also encourage economies of production by allowing larger, longer and more production runs. Production output can be decoupled from the variation in demand because inventories act as a buffer between two.

Maintenance of operational capability:

One of the advantages of stocking inventory of raw material and work-in-progress items is to link various production stages so that downtime in one stage does not affect the entire production process. It helps to continue the production by acting as buffer between successive stages of production.

Irregular supply and demand:

Any change in the production and delivery schedule of a product or a service has its impact on the operating costs as well as the customer service level. A sufficient level of inventory and efficient delivery schedules can improve customer service level by meeting the customer's immediate and seasonal needs.

Quantity discounts:

Large size replenishments orders help to take advantage of price-quantity discount because many suppliers offer discounts for large orders. However such an advantage must keep a balance between the storage costs and cost due to spoilage, damaged stock, theft, insurance, etc. Investment on large stock of inventory items due to bulk purchase, however, reduces cash that can be used for other purposes.

Avoiding stock outs or shortages:

Inventories can afford some protection against some of the types of contingencies such as, Labour strikes, natural disasters, variations in demand, and delays in supplies.

A company also requires large inventories in order to avoid the reputation of constantly being out of stock. Lost goodwill can be an expensive price to pay for not having the right item at the right time and therefore inventories help in avoiding shortage at a minimum cost.

Factors involved in inventory problem analysis are given below:

A number of factors must be considered while analyzing inventory problems. Among the most important are the following:

- Relevant inventory costs
- Replenishment lead time
- Constraints on the inventory system
- Demand for inventory items
- Length of planning period

Regardless of the type of inventory items maintained, an inventory system comprises the following subsystems:

Replenishment pattern:

In a manufacturing system, the inventory of raw material, semi-finished goods, etc. may be required either to keep in warehouse for future need or to be used for immediate processing on arrival.

The replenishment of such items may be instantaneous, constant or gradual, depending upon the lead time.

Inventory system's performance:

The performance of an inventory system is related to the inventory costs. These costs are often not directly reflects in a firms financial statements. Therefore a system's performance is sometime measured in relation to inventory turnover.

High inventory turnover indicates a large return on the inventory. But analysis of various cost associated with the inventory of a firm indicates that the inventory turnover is a comprehensive measure of inventory system performance. This is because these costs are affected by the inventory management decisions.

Several inventory costs that are not reflected by the inventory turnover include ordering cost, cost of carrying inventory, cost of shortage and other customer services costs.

Operating constraints:

The stock level of various items in the inventory is governed by various constraints such as limited warehouse space, limited budget available for inventory, degree of management attention towards individual items in the inventory and customer service level to be achieved.

Operating decision rules:

Two types of managerial decisions need to be made in order to determine efficient inventory policy. A key element in designing such a policy is to determine,

- Order quantity that is units of an item to be ordered or produced for each replenishment, and
- Time of an order to replenish inventory

Decisions regarding the size and timing of replenishment orders are influenced by the following four main factors:

- The forecast of demand for an item
- Its replenishment lead time
- The inventory related cost for the item and
- Management policies

Decisions on the size and timing of replenishment orders for an item can be made by adopting the following basic inventory control policies or systems:

Continuous review system and periodic review system.

Continuous review system is an inventory system where the current inventory level is monitored on a continuous basis.

Periodic review system is an inventory system where inventory level is only checked periodically.

<u>5. Cost Components of Inventory</u>

The costs that are affected that are increase or decrease by the firm's decision to maintain a particular level of inventory are called relevant costs. These costs definitely play an important role in the study of an inventory system.

These are classified as follows: **Purchase cost:**

This cost consists of the actual price paid for the procurement of items.

Its unit of measurement is Rs per unit. The unit price C of an item is independent of the size of the quantity ordered or purchased or manufactured.

When price-break or quantity discounts are available for bulk purchase above a specified quantity, the unit price becomes smaller as the size of order Q, exceeds a specified quantity level. In such cases the purchase cost become variable and depends on the size of the order.

Carrying or holding cost:

These are the expenses incurred carrying or holding inventory items in the warehouse. They include,

- Storage cost for providing warehouse space to store the products,
- Inventory handling cost for payment of salaries to employees
- > Insurance cost against possible loss from fire or other form of damage
- > Opportunity cost of the money invested in inventory

> Obsolescence and deterioration costs when a portion of inventory becomes either obsolete or is lost or pilfred

Depreciation, etc

Ordering or set-up cost:

Ordering cost includes all cost that does not vary with the size of the order but are incurred each time an order is placed for procuring items from the outside suppliers.

The cost per order generally include,

- Requisition cost of handling of invoices, stationary, payments, etc
- Cost of services which includes cost of mailing, telephone calls, transportation and other follow up actions

> Materials handling cost incurred in receiving, sorting, inspecting and storing the items included in the order

Accounting and auditing, etc

When an item is produced 'in-house', ordering cost is referred as set-up cost, which includes both paper work costs and the physical preparation costs.

Shortage or stock out and customer service cost:

The shortage of items occurs when items cannot be supplied on demand.

The shortage can be viewed in two different ways: the supply of items is awaited by the customer that is the items are back ordered and when customers are not ready to wait.

One of the frequently used measures for inventory shortage costs is the level of customer service achieved on meeting the product demand, which is percentage of demand that is met from inventory upon demand.

Total Inventory Cost:

If a unit of an item depends on the quantity purchase, that is price discounts are available, then we should formulate an inventory policy what takes into consideration the purchase cost of the items also held in stock. When price discounts are not offered, the purchase cost remains constant and is independent of the quantity purchased.

Let us now discuss on Inventory Model building:

An inventory control problem can be solved using several methods, starting from trial-and-error method to mathematical and simulation models.

Mathematical models help in deriving certain rules that may suggest how to minimize the total or incremental inventory cost in case of deterministic demand or how to minimize expected cost in case of probabilistic demand.

Steps of inventory model building are as follows:

Step 1: Collect the data regarding the pattern of demand, the replenishment policy, planning period, relevant inventory costs, etc.

Step 2: Build up a mathematical model or some appropriate relationships using the above information, which can be representative of the behaviour or objective of the inventory system.

Models so developed may have an objective function of minimizing the total inventory costs subject to changes in inventory reorder policy and constraints of limited resources such as floor space for storage, capital investment, etc.

Thus, the model would either be an unconstrained or constrained optimization model, depending upon whether the constraints are imposed or not.

Step 3: Derive an optimal inventory policy that is economic order quantity by using an appropriate solution procedure so as to maintain balance amongst the inventory costs.

Here's a summary of our learning in this session, where we have understood:

- The meaning of inventory control
- The forms and functional role of inventory