# Inventory Management

## Learning Outcomes

**By the end of this unit the learner will be able to:**

- ✓ Understand what is Inventory Management
- ✓ Explore how to Develop Economic Order Quantity

# Inventory Management

An **INVENTORY** is generally described as goods and products businesses hold to resale them to end users.Stocks are finished goods and products or sometimes, there are raw materials that businesses hold in order to sell to the end-user (customers). The procurement department is responsible for controlling flow of raw material into an organization but the purchase timing and quantity of material to be purchased are critical to decide. This section will try to explore these critical issues, which are the major part of inventory management policies. Although stock keeping is essential yet the delay in material flow also causes the formation of stock. Every organization keeps stock, no matter what the nature of the business is.

## Buffering Supply and Demand

Although maintaining the limited amount of stock is appreciated, yet many businesses are bound to have huge stock. For instance, a crop grown by a farmer once a year is kept to sell and fed animals for the entire year. A whisky is stored by a distiller in barrels for at least three years before making it available for sale. A video shop owner keeps hundreds and thousands of copies of movies until people like to buy them. There is no need to get rid of stock; however, controlling stock is the prime requirement for any business.

The main cause for keeping stocks is to provide a buffer between variable –and sometimes unambiguous – supply and demand Think of food delivered to a superstore, which is usually delivered in large amount– maybe a truckload at a time – however only a smaller quantity is sold to individual customers. The consequence is a stock that is replenished with each delivery, and is reduced with the passage of time in order to coincide with demand. The stocks grant a cushion between supply and demand. They enable the supermarket to keep working efficiently, even when transportation of goods is delayed or if a sudden higher demand from customers arise.

The major motive of keeping STOCKS is to make it act as a buffer between supply and demand.

They let operations to continue easily and evade disruptions.

Stocks specifically -

- act as a buffer between various operations of supply chain;
- helps in estimating unexpected demands or at unexpected times;
- controls small or delayed deliveries;
- gives a benefit of price discounts on bulky orders;
- enables to purchase stock at lower prices which are expected to rise;

- eases the purchase of rarely available;
- allows to manage seasonal operations effectively;
- reduces goods transportation costs;
- provides shield during emergencies; and
- may be more profitable during periods of higher inflation

## Types of Stock

Since everything is held as stock, whether it is in the form of raw materials in a manufacturing factory finished products in a shop or baked beans tins in a pantry, we can categorize these stocks as:

- **Raw materials:** The materials, components and parts that organizations purchase for making finished products or reselling to end customers.
- **Work in process:** Material that is still in production phase. It is not finished.
- **Finished goods:** These are finished products and are waiting to be delivered to end customers.

This is a quite arbitrary categorization, as one organization's finished goods are raw materials of some other company. Some organisations, mainly retailers and wholesalers, usually keep stocks of just finished goods, while most of the manufacturing businesses, and keep all three types in different quantities. Nationally, approximately 30% of stocks are raw materials, 40% work in progress and 30% finished goods. Some stock items do not fall simply into these categories, and we can classify two further types:

- **Spare parts** used in machinery, appliances, equipment, and so on
- **Consumables** like oil, chemicals, fuel, and paper, etc.

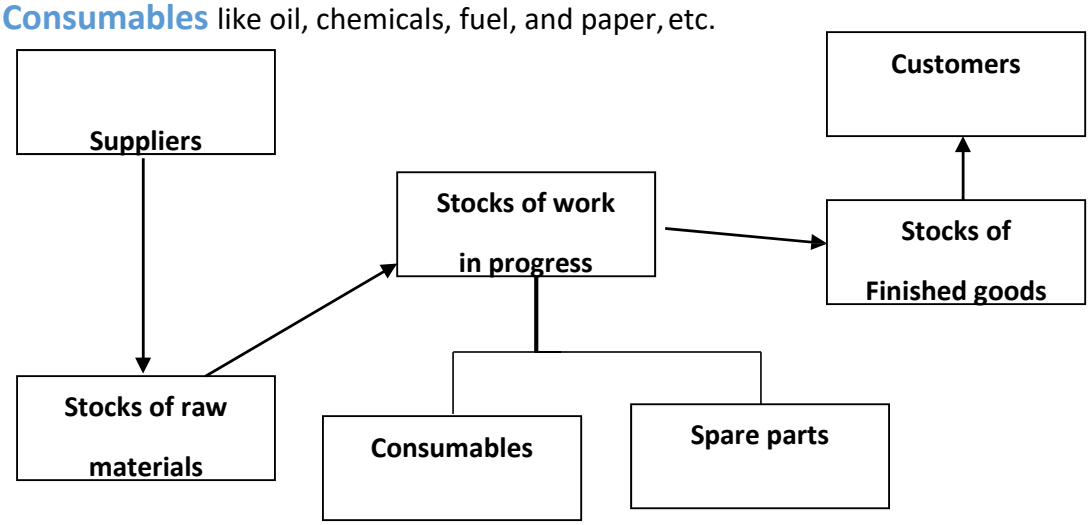


***Figure 1.1 Types of stock***

The overall demand in a market is consisted of lots of demands from individual customers. Independent demand systems regulate stocks by finding the finest balance between ranges of costs. In particular, they try to find answers for these three basic questions:

1. *What items should we stock?* No item, even if it is cheap, should be stocked without bearing in mind the costs and its benefits. It means businesses needs to stock unnecessary new items, and it should make appropriate searches to eliminate outdated or dead stock.
2. *When should we order for stock?* This depends on the system being used for inventory control, type of demand (high or low, stable or erratic, known accurately or estimated), worth of the item, lead time between order placement and its delivery supplier reliability, and some other factors.
3. *How to decide quantity to be ordered?* Large, occasional orders usually result in high average stock levels, but lower costs for placing and managing orders: small, recurrent orders result in low average stocks, but usually accompanied with high costs of placing and managing. The first of these questions is a matter of good maintenance, only avoiding stock that is not required. The next section will find answers to the last two questions.

## Costs of Carrying Stock

The average total cost of holding stock most of the businesses have to incur is estimated as twenty five percent a year. A reasonable goal is to reduce this cost as much as possible. You might think – particularly after the lessons of just-in-time – that reducing costs is the same as reducing stocks. But this is not essentially true. If a shop keeps zero stock, it certainly is not incurring any stock cost, but it also has no sales; it efficiently incurs another cost i.e. losing its customers.

Lambert explains one approach which describes the costs of capital (for borrowing and opportunity etc.), inventory service (insurance and taxes etc.), storage (rent and heating, etc.) and risks associated with inventory (obsolescence and damage, etc.). We will use somewhat different approach that splits the entire stock cost into four individual components.

1. **Unit Cost:** The price charged by the supplier for an item purchased or the cost incurred by an organisation to purchase one unit of the item. It may be quite easy to find this by reviewing quotations or latest invoices from suppliers, but it is harder when there are a number of suppliers offering little different products, or offering diverse purchase conditions. If a business makes the product itself, it might be difficult to give a consistent production cost or decide a transfer price.
2. **Reorder Cost:** The cost organisation incurs for placing repeat order. This might contain allowances for preparing an order, communication, receiving, delivery, checking, testing, utilization of equipment and follow-up. Sometimes, costs like quality control, transport, categorization and mobility of received goods are also included. In practice, the best approximation for a reorder cost

usually comes from dividing the annual cost of the purchasing department by the number of orders sent out.

3. **Holding Cost**: It is the cost of keeping one unit of stock for a unit period of time – for instance, the cost incurred by Air France to hold a spare engine in stock for one year. The apparent cost is tied-up money. This is either borrowed (there are interest payments) or it is cash that could be used somewhere else (there are opportunity costs). Other holding costs result due to storage space, loss, handling, and special treatment, for example refrigeration, insurance and administration. Another problem is obsolete material. It is the stock that was kept so long that it lost value, like obsolete spare parts or expired food Products having shorter life cycles, may have faster obsolescence. On the other hand, if your materials are being moved much faster through supply chains, then in many conditions the amount of obsolescence is declining. It is complex to give distinctive values for these, but a rule for annual costs as a percentage of unit cost, has:

   a. **% of unit cost**

      Cost of money 10–15

      Storage space 2–5

      Loss and obsolescence 4–6

      Handling 1–2

      Administration 1–2

      Insurance 1–5

      **Total 19–35**

4. **Shortage Cost:** it occurs if a business is purchasing an item which is not available in stock anymore, or we can say, there is a shortage of that item. In the simplest case a retailer is unable to get direct profit from a sale. But the impacts of shortages are generally more widespread and may result in lost goodwill, loss of reputation, and loss of prospective future sales. Stock shortages can cause disturbance, rescheduling of production, re-timing of maintenance periods, and laying off workers. Shortage costs may also include payments for constructive action to remedy the scarcity, such as expediting orders, sending out urgent orders, paying for particular deliveries, storing partially finished goods or using more costly suppliers. It can be hard to get statistics for any inventory costs, but shortage costs are the major problem. These can also result in a number of intangible factors, like lost goodwill, that it is difficult to agree a rational value. Most organisations consider shortages expensive, and they generally like to avoid them. In other words, they are prepared to pay the comparatively lower costs of carrying costs to avoid the fairly higher costs of shortages. As you can see, this tends to increase the quantity of stock held, mainly when there is uncertainty.

# Economic Order Quantity

## Finding the Order Size

The **Economic Order Quantity** (EOQ) is one of the earliest concepts emerged in early last century and still is a central theme for regulating the independent demand systems. It remains the finest way of tackling a broad range of inventory related problems. It is flexible and simple to use, and gives excellent guidelines for a number of circumstances.

Consider a single item, kept in stock to meet a steady demand of D per unit time. Assume that unit cost (U), reorder cost (R) and holding cost (H) are all identified exactly, while the shortage cost is so high requiring all the demands must be met and no shortages should be there The item is purchased in batches from a supplier who delivers after a stable lead time. We want to discover the best order quantity, Q, and always put orders of this size.

There is no point in keeping spare stock, so time orders to arrive just as stock at hand runs out. At some point an order of size Q arrives. This is used at a constant rate, D, until no stock is left. We can find the total cost for the cycle by adding the four components of cost – unit, reorder, holding, and shortage. Since there is no shortage allowed, we can ignore this cost and the cost of buying the item is constant regardless of the ordering policy, so we can also leave the unit cost out of the calculations.

Then, we can show that the cost per unit time is:

C = total reorder costs + total holding costs

= RD/Q + HQ/2

A standard analysis shows that the economic order quantity is found from the following equation:

Where D = demand

R = reorder cost

H = holding cost

Economic order quantity, $Q = \sqrt{2RDH}$

## Finding the Time to Place Orders

At the time of buying materials, there is a **lead time** between placing the order and its delivery to the company's store rooms. . This is the time an order takes to be prepared and sent to the supplier. This time allows the supplier to make or accumulate the materials and organize them for shipment, ship the goods back to the client, allow the client to receive and verify the materials and put them into stock. Depending on situation, this lead time can differ. Suppose the lead time, represented by L, is constant. To make sure

that a delivery arrives just as stock is running out, we have to put an order a time L earlier. The easiest way of finding this point is to check current stock and place an order when there is just an adequate amount left to last the lead time. With constant demand, D, this means that we place an order when the stock level falls to LD, and this point is called the **reorder level**.

Reorder level = lead time demand = lead time x demand

ROL = LD

In practice, the inventory control system helps to have a continuous record of the current stock, update this with each transaction and sends a message when the time for placing an order arrives.

Normally, this message is sent to a procurement department; with e-procurement or some sort of alliance the message is sent directly to the supplier; with ECR systems the message is sent both to the supplier and other relevant divisions down the supply chain.

This calculation works well provided the lead time is less than the length of a stock cycle.

In the next example the lead time is two weeks and the stock cycle is 50/20 = 2.5 weeks.

Suppose the lead time is raised to three weeks. The calculation for reorder level then becomes:

Reorder level = lead time x demand = LD = 3 x 20 = 60 units

The difficulty is that the stock level never essentially rises to 60 units, but keeps changing between 0 and 50 units. The way around this trouble is to know that the calculated reorder level refers to both present stocks on order. Then the reorder level equals lead time demand minus any stock that is already on order. In the example above, the order quantity is 50 units, so a lead time of three weeks would have one order of 50 units outstanding when it is time to place another order. Then:

Reorder level = lead time demand – stock on order = LD – Q

= 3 x 20 – 50 = 10 units

An order for 50 units is recommended to be placed whenever on hand stock declines to 10 units. Because the lead time is longer than the stock cycle, there will always be at least one order outstanding, one hitch, of course, is that the lead time may not be stable. We know how long the lead time has been in the past, and we know the current target, but there may be some unpredictability and the supplier might not always attain this target. As well as forecasting the demand needs, we also have to predict the lead time, so the reorder level is, in fact, based on two forecasts.

## Sensitivity Analysis

One issue with the economic order quantity is that it can result in awkward order quantities. It may, for instance, suggest buying unrealistic figures, like 88.39 tyres. We could round this to 88 tyres, but we may

prefer to order 90 or even 100. But does this rounding have much effect on total costs? In practice, the total cost curve is always shallow around the economic order quantity. The amount we order can increase to 156% of the economic order quantity or fall to 64% and only raise variable costs by 10%. Similarly, the order quantity can increase to 186% of the economic order quantity or fall to 54% and only raise variable costs by 20%. This is one reason why the EOQ analysis is so widely used – although the calculation is based on a series of assumptions and approximations, the total cost rises slowly around the optimal. EOQ gives a good guideline for order size in a wide range of circumstances

## Weaknesses of this Approach

The concept of economic order quantity has been employed since a century, and is still the foundation for most independent demand inventory systems. It offers many advantages, such as:

- simple to understand and use
- giving superior guidelines for order size
- finding other values like costs and cycle lengths
- easy to execute and computerize
- encouraging stability
- it easy to expand allowing for diverse circumstances

On the other hand, there are a number of weaknesses, as it:

- takes a basic view of inventory systems
- assumes demand is identified and constant
- assumes all costs are known and unchanging
- assumes a stable lead time and no vagueness in supplies
- gives awkward order sizes at changing times
- assumes every item is independent of others
- does not promote improvement, unlike JIT

## Uncertain Demand and Safety Stock

The basic economic order quantity assumes that demand is stable and known exactly. In practice demand can differ widely and have a lot of ambiguity. A company selling a new CD, for instance, does not know how many copies will sell in advance or how sales will differ over time.

When the difference is small, the EOQ Model still gives valuable results, but they are not so good when demand changes more widely. There are a number of ways we can deal with changeable and uncertain demand and we will demonstrate one approach where the demand is normally distributed.

You can see easily why our previous calculations are not effective to apply with a variable demand. We used a reorder level found from the mean demand in the lead time. But if demand in the lead time is above average, there will be a shortage before the next delivery arrives and there will be shortages. Unfortunately, when demand is, say, normally distributed, it is above the mean in 50% of cycles. Most organisations would not be happy with shortages in 50% of stock cycles. A solution is to hold additional stocks – above the expected needs – to add a margin of safety. Then organisations boost their holding costs by a small amount, to evade the higher shortage costs. These **safety stocks** are used if the normal working stock runs out. They have no effect on the reorder quantity – which is still defined by the EOQ – but do affect the time when an order is placed. In particular, the reorder level is raised by the amount of the safety stock to give:

**REORDER LEVEL** = lead time demand + safety stock = LD + safety stock

Higher safety stocks apparently give a greater cushion against unexpectedly high demand, and better customer service. Of course, the costs of holding larger stocks are also higher, so we have to balance these two effects. The problem is that shortage costs are so difficult to find that they are little more than guesses. An alternative approach relies on managers' judgement to set an appropriate **service level**. This is the probability that a demand is met directly from stock. An organisation typically gives a service level of 95%. This means that it meets 95% of orders from stock – and accepts that 5% of orders cannot be met from stock. The service level needs a positive decision by managers, based on their experience, objectives, competition, and knowledge of customer expectations.

## Periodic Review Systems

The EOQ analysis utilizes a fixed order quantity for buying, hence whenever needed; a fixed size order is placed.

A heating plant may order 25,000 litres of oil whenever the amount in the tank falls to 2,500 litres. Such systems need to have regular monitoring of stock levels and are best suited to low, irregular demand for relatively expensive items. But there is an alternative **periodic review** approach, which orders varying amounts at regular intervals. A supermarket might refill its shelves every evening to restore whatever it

sold during the day. This system entails lower operating cost and it is the best approach for low value items having high but regular demand.

If the demand is steady these two systems act like same, but vary when there is any difference in demand. . We can show this by extending the last analysis, and looking at a periodic review system where demand is normally distributed. Then we are looking for answers to two questions. First, what should be the interval between two orders placement? This can be any convenient time, and organisations typically place orders at the end of every week, or every morning, or at the end of a month. If there is no obvious cycle we might aim for a certain number of orders a year or some average order size. One approach is to calculate an economic order quantity, and then find the period that gives orders of about this size. This decision is largely a matter for management judgement.

Secondly, how can we decide what to set the target **stock level**? The system works by looking at the stock on hand when an order is due, and ordering an amount that brings this up to a target stock level.

Order quantity = target stock level – stock on hand

Supermarkets usually use periodic review, and with EDI you can envision a store where the tills pass messages every night to replenish products that were used during the day. But the system becomes more responsive and reduces stock levels, if it sends messages, say, two or three times a day. Suppliers consolidate these orders and send deliveries as often as necessary.

# Effort of Stock Control

## ABC Analysis

No matter if you have highly automated and simplest inventory control system, you still need some efforts and tricks to run it effectively.

For some items, especially cheap ones, this effort is not worthwhile.

Only a limited number of organisations include, for example, routine stationery or nuts and bolts in their stock control system. At the other end of the scale are very expensive items that need special care above the routine calculations. Aircraft engines, for example, are very expensive, and airlines have to control their stocks of spare engines very carefully.

An **ABC analysis** defines the categories of items that exhibit the extent of efforts that should be applied for inventory control. This is a standard Pareto analysis or ‘rule of 80/20’, which suggests that 20% of inventory items need 80% of the attention, while the remaining 80% of items need only 20% of the attention. ABC analyses define:

- A items as expensive and needing special care;
- B items as ordinary ones needing standard care; and

- C items as cheap and needing little care.

Organisations usually utilize automated system to handle B items. The system might make some suggestions for A items, but decisions are made by managers after reviewing all the circumstances. On the other hand, C items are controlled by ad hoc methods.

An ABC analysis starts by calculating the total annual use of each item by value. We find this by multiplying the number of units used in a year by the unit cost. Usually, a few expensive items account for a lot of use, while many cheap ones account for little use.

## Vendor Managed Inventory

If an organisation is unable to apply required level of efforts to its inventory control system, it outsources this function to a third party. It gives them advantages like cost reduction both in terms of money and efforts. Perhaps the most common arrangement of this kind is **vendor managed inventory**. Take an example of departmental store that stocks shoes. Ordinarily the store controls its own stocks, and orders more from a wholesaler when it wants them. With vendor managed inventory, the wholesaler controls the stocks, and sends more along when they are needed. The benefits of such arrangements include enhanced co-ordination for stocks covering wider area, achieving optimal inventory policies.

Transport organizing transport more efficiently, increasing integration in the supply chain, gathering more information about demand patterns, and delivering a consistent customer service. The drawbacks are more reliance on a supplier having diverse objectives, less clear liability for stock, need for more refined information systems, and less flexibility.

### Further Reading:

- ✓ Max Muller, (2011), Essentials of Inventory Management
- ✓ Sven Axsäter, (2006), Inventory Control