UNIT-8

Inventory Management

Learning Outcomes

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

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

Unit 8

Inventory Management

An **INVENTORY** is generally described as the goods and products businesses hold to sell tham on to end users. Stocks are finished goods and products, or sometimes raw materials that businesses hold in order to sell to the end-user (customer). The procurement department is responsible for controlling flow of raw materials into an organization, but the purchase timing and quantity of materials to be purchased are critical decision. This section will begin to explore these critical issues, which are major parts of inventory management policies. Stock maintenance is essential, but delays in the flow of materials can also cause formation of stock. Every organization keeps stock, no matter what the nature of the business is.

Buffering Supply and Demand

Although maintaining a limited amount of stock is advantageous, many businesses are requird to have huge amounts of 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 movie shop owner keeps hundreds or thousands of copies of movies until people buy them. There is no need to get rid of stock, but at the same time, controlling stock is a prime requirement for any business.

The main reason for keeping stocks is to provide a buffer between variable –and sometimes unambiguous – supply and demand. Think of the food delivered to a superstore, which is usually delivered in large amounts – maybe a truckload at a time – but only a smaller quantity is sold to individual customers. The result is a stock level that is replenished with each delivery and reduced with the passage of time, in order to coincide with demand. On-hand stocks provide 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 increase in demand from customers was to arise.

The major motive of holding stocks is to serve as a buffer between supply and demand.

It lets operations to continue easily and prevents disruptions.

Stocks specifically -

- act as a buffer between various supply chain operations;
- help cope with unexpected demand at unexpected times;
- compensate for small or delayed deliveries;
- provide the benefit of price discounts on bulky orders;

- enable the purchase of stock at lower prices before expected increases;
- ease the purchase of rarely available materials and products;
- allow businesses to manage seasonal operations effectively;
- reduce goods transportation costs;
- provide protection during emergencies;
- can 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 factory, finished products in a shop or soup cans in a pantry, we can categorize these stocks as:

- **Raw materials:** The materials, components and parts that organizations purchase for making finished products, or to resell to end customers.
- **Work in process:** Material that is still in the production phase an unfinished.
- **Finished goods:** Finished products that are waiting to be delivered to end customers.

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

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

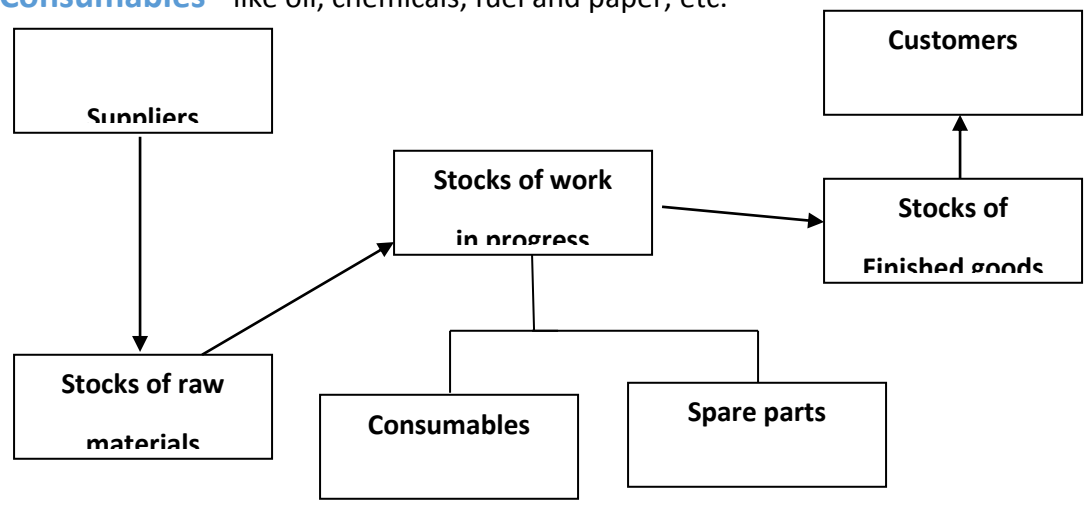


Figure 6.1 Types of stock

The overall demand in a market is comprised of cumulative demands from individual customers. Independent demand systems regulate stocks by finding the best balance between ranges of costs. In particular, they try to find answers to 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. This means businesses need to stock up on necessary new items, while making appropriate efforts to eliminate outdated or dead stock.
2. *When should we order stock?* This depends on the system being used for inventory control, type of demand (high or low, stable or erratic, known accurately or estimated), value of the item, lead time between order placement and its delivery supplier reliability and many other factors.
3. *How to decide on the quantity to be ordered?* Large, occasional orders usually result in high average stock levels, but lower costs for placing and managing orders. By contrast, small and recurrent orders result in low average stocks, but are usually accompanied with higher costs of placing and managing orders.

The first of these questions is about good maintenance management, avoiding stock that is not required. The next section will explore answers to the subsequent two questions.

Costs of Carrying Stock

The average total cost of holding stock most businesses 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 definitely is not incurring any stock cost, but it also has no sales and quickly incurs another cost; 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 take a 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 simple to find this by reviewing quotations or latest invoices from suppliers, but it is harder when there are a number of suppliers offering various 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 an organisation incurs for placing repeat orders. This might include allowances for preparing the order, communication, receiving, delivery, checking, testing, utilization of equipment and follow-ups. Sometimes, additional 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 total annual cost by the number of orders sent out.
3. **Holding Cost**: Refers to the cost of keeping one unit of stock for a specific 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 (interest payments) or it is cash that could be used somewhere else (opportunity costs). Other holding costs apply due to storage space, loss, handling and special conditions; refrigeration, insurance and administration, for example. Another problem is obsolete material. It is stock that has been kept so long that ithas lost value, like obsolete spare parts for vehicles or expired food products. On the other hand, if your materials are being moved much faster through supply chains, then in many conditions the level of obsolescence is much lower. It is difficult to give distinctive values for these, but a general rule of thumb for annual costs as a percentage of unit cost has:
    a. **% of unit cost**

       Cost of financing 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:** This occurs if a business is purchasing an item which is not available for a period of time, or there is a shortage of that item. In the simplest case, a retailer is unable to obtain direct profit from a missed sale. But the impacts of shortages are generally more widespread and may result in lost faith, loss of reputation and loss of prospective future sales. Stock shortages can cause disturbance, rescheduling of production, re-timing of maintenance periods and even the laying off of workers. Shortage costs may also include payments for action taken to remedy the problem, 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 a loss of trust and customer loyalty, that it is difficult to put to 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 stocks to avoid the 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 to have emerged in early last century and still is a central theme for regulating independent demand systems. It remains the best way of tackling a broad range of inventory related problems. It is flexible and simple to use, and gives very useful guidelines for a number of circumstances.

Consider a single item, kept in stock to meet steady demand (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 that it requires all demands to be met and allows for no shortages. 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 place orders of this size.

There is no point in keeping spare stock, so instead it makes sense to time orders to arrive just as stock on 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, which means 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

Standard analysis shows that the economic order quantity is found using 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 time to receive and verify the materials and ultimately put them into stock. Depending on the situation, this lead time can differ significantly. 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 place each 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, ann inventory control system helps by providing a continuous record of the current stock, updating this with each transaction and sending 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 issue is to know that the calculated reorder level refers to both present stocks and 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

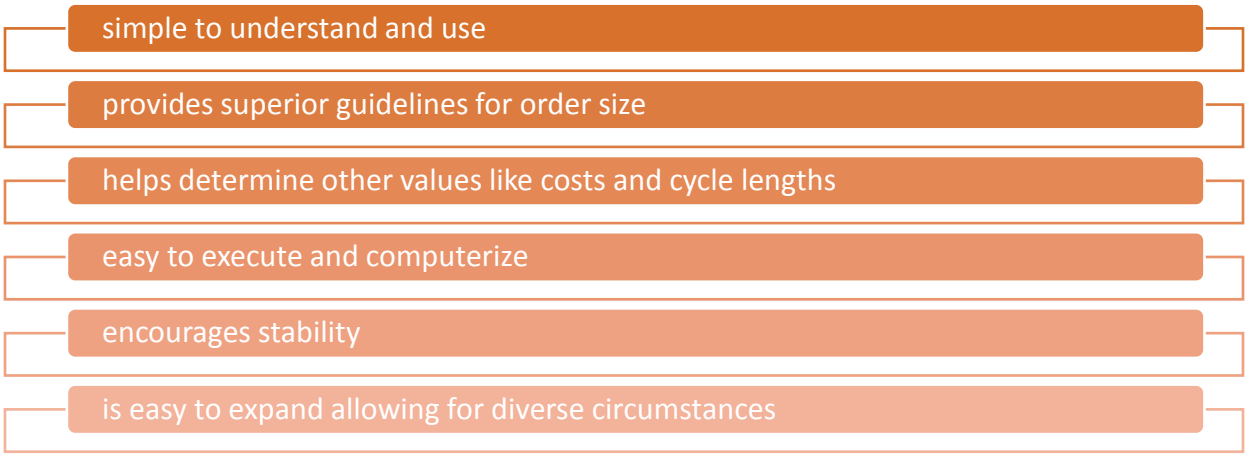
in the past and we know the current target, but there may be some unpredictability and the supplier might not always reach this target. As well as forecasting demand, we also have to predict the lead time, so the reorder level is, in fact, based on two forecasts.

Sensitivity Analysis

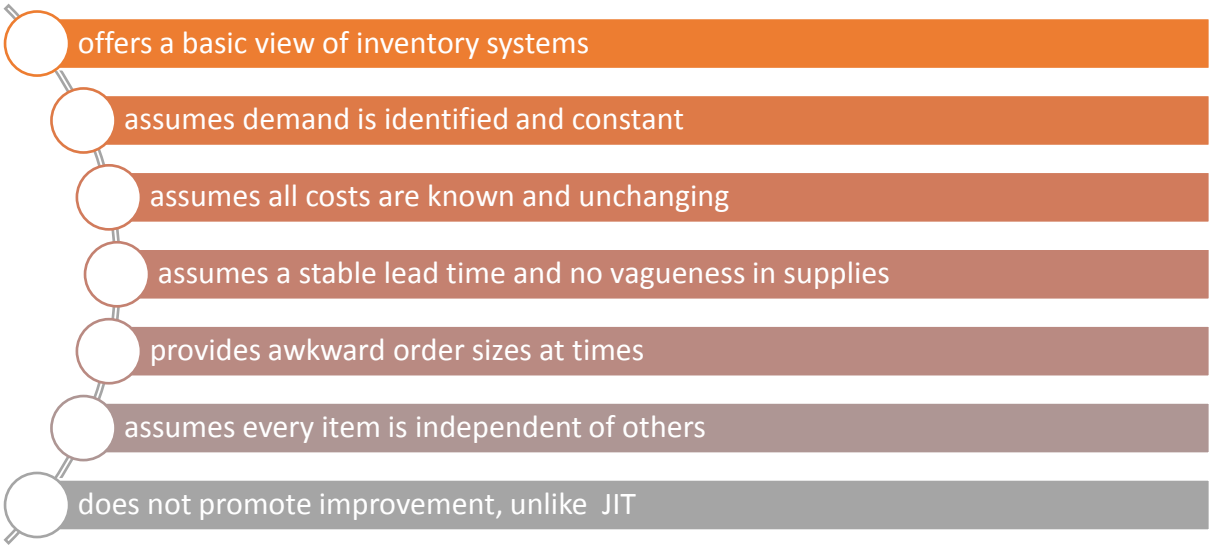
One issue with economic order quantity is that it can result in awkward order quantities. It may, for instance, suggest buying unrealistic figures, like 88.39 tyres. We could round this to 88 tyres, but we may prefer to order 90 or even 100. But does this rounding have much effect on total costs? In 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 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 used for over a century and is still the foundation for most independent demand inventory systems. It offers many advantages, such as:



On the other hand, there are a number of weaknesses to consider, which include how it:



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 demand is normally distributed.

You can see easily why our previous calculations are not effective when dealing with 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 stock shortages as a result. Unfortunately, when demand is 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 increaase their holding costs by a small amount, in order 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 clearly give a greater cushion against unexpectedly high demand, allowing for better customer service. Of course, the costs of holding larger stocks are also higher, so we have to balance these two elements. The problem is that shortage costs are so difficult to determine that they are little more than educated guesses. An alternative approach relies on managers' judgement to set an

appropriate **service level**. This is the probability that 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. Determining service level requires a decisive decision by managers, based on their experience, objectives, competition and knowledge of customer expectations.

Periodic Review Systems

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 offers 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 previous analysis, while 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 order placements? This can be any convenient time, and organisations typically place orders at the end of every week, 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 of 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 primarily a matter for management judgement.

Secondly, how can we decide how 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 reviews, and with EDI you can envision a store where the cash registers 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 two or three times a day, for example. Suppliers consolidate these orders and send deliveries as often as necessary.

Effort of Stock Control

ABC Analysis

Even if you have a highly-automated and simple inventory control system, you still need to make the necessary efforts 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.

ABC analysis defines the categories of items that exhibit the extent of efforts that should be applied for inventory control. This is 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 refers to:

- A - items expensive enough to need special care;
- B - ordinary items needing standard care;
- C - cheap items needing little care.

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

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 the required amount of effort to its inventory control system, it outsources this function to a third party. This gives them advantages like cost reduction, both in terms of expenditure and effort. Perhaps the most common arrangement of this kind is **vendor managed inventory**. Take the example of a departmental store that stocks shoes. Ordinarily, the store controls its own stocks and orders more from a wholesaler when it needs 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 a wider area, achieving optimal inventory policies.

It also becomes possible to organize transport more efficiently, increase integration in the supply chain, gather more information about demand patterns and delivering consistent customer service. The drawbacks are more reliance on a supplier having diverse objectives, less clear liability for stock, the need for more refined information systems and less flexibility.

Further Reading:

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