Engineering Management

Inventory Management

Inventory management

Inventory management is a core operations management activity.

Effective inventory management is important for the successful operation of most businesses and their supply chains, and impacts operations, marketing, and finance.

Poor inventory management, however, hampers operations, diminishes customer satisfaction, and increases operating costs.

Some organizations have excellent inventory management, and many have satisfactory inventory management. Too many, however, have unsatisfactory inventory management. They either have too little or too much inventory, inaccurate inven- tory tracking, or incorrect priorities. What is lacking is an understanding of what needs to be done and how to do it. This chapter presents the concepts and knowledge base for effective inventory management.

Introduction

- An **inventory** is a stock or store of goods.
- Firms typically stock hundreds or even thousands of items in inventory, ranging from small things such as pencils, paper clips, screws, nuts, and bolts to large items such as machines, trucks, construction equipment, and airplanes.
- Naturally, many of the items a firm carries in inventory are related to the business it engages in.
- Thus, manufacturing firms carry supplies of raw materials, purchased parts, partially finished items, and finished goods, as well as spare parts for machines, tools, and other supplies.
- Department stores carry clothing, furniture, carpeting, stationery, cosmetics, gifts, cards, and toys.

Introduction (contd.)

- Some also stock sporting goods, paints, and tools.
- Hospitals stock drugs, surgical supplies, life-monitoring equipment, sheets, and pillow cases, and more.
- Supermarkets stock fresh and canned foods, packaged and frozen foods, household supplies, magazines, baked goods, dairy products, produce, and other items.
- The amounts and dollar values of inventories carried by different types of firms vary widely, a typical firm probably has about 30 percent of its current assets and perhaps as much as 90 percent of its working capital invested in inventory.

Types of inventories

Types of inventories include the following:

- Raw materials and purchased parts
- Partially completed goods, called work-in-process (WIP)
- Finished-goods inventories (manufacturing firms) or merchandise (retail stores)
- Tools and supplies
- Maintenance and repairs (MRO) inventory
- Goods-in-transit to warehouses, distributors, or customers (pipeline inventory)

Both manufacturing and service organizations have to consider the space requirements of inventory.

In some cases, space limitations may restrict inventory storage capability, thereby adding another dimension to inventory decisions.

Functions of inventories

Inventories serve a number of functions:

* **To meet anticipated customer demand**

A customer can be someone who walks in off the street to buy a new smartphone, a mechanic who requests a tool at a tool crib, or a coffee shop that stocks coffee for the expected demand (Showrooms of Rangs Electronics, Restaurants, etc.)

* **To smooth production requirements**

Firms that experience seasonal patterns in demand often build up inventories during pre-season periods to meet overly high requirements during seasonal periods (IGLOO and other ice cream companies)

Functions of inventories (Contd.)

Inventories serve a number of functions:

* **To decouple operations**

Manufacturing firms keep buffer stock to tackle any disruption in the operation.

The buffers permit other operations to continue temporarily while the problem is resolved (Cement factories)

* **To protect against stockout**

Unexpected increases in demand increase the risk of shortages.

Delays can occur because of weather conditions, delayed deliveries, quality problems etc.

The risk of shortage can be reduced by holding safety stock.

Functions of inventories (Contd.)

Inventories serve a number of functions:

- **To take advantage of order cycles**

To minimize purchasing cost, firms often buy more than current requirement. They use this additional quantity for later production.

This enables the firms to buy or produce in economic lot sizes without trying to match purchases or production with demand requirements in the short run.

This results in order cycle.

- **To hedge against price increase**

When firms sense any possibility of price increase, they purchase larger than normal amounts to beat the increase.

The ability to store extra goods allow the firms to take the advantage of discount for larger orders (Agreement between DIPON and Paradise Cables to supply cable for Haripur Compressor Station work)

Functions of inventories (Contd.)

Inventories serve a number of functions:

* **To permit operations**

Inventory of raw material, semi-finished goods and finished goods as well as goods stored in warehouses allow the operation to continue at different stages.

* **To take advantage of quantity discount**

Suppliers may give discounts on large orders, opening the possibility of saving money by purchasing goods in large quantities

Inventory Counting Systems

Inventory counting systems can be **periodic** or **perpetual**.

Under a **periodic system**, a physical count of items in inventory is made at periodic, fixed intervals (e.g., weekly, monthly) to decide how much to order for each item.

Many small retailers use this approach.

Then, the manager estimates how much will be demanded before the next delivery period and bases the order quantity on that information.

An advantage of this type of system is that orders for many items occur simultaneously, which can result in economies in processing and shipping orders.

There are also several disadvantages of periodic reviews.

One is a lack of control between reviews.

Another is the need to protect against shortages between review periods by carrying extra stock.

Inventory Counting Systems (Contd.)

A **perpetual** inventory system (also known as a **continuous review system**) keeps track of removals from inventory continuously so that the system can provide information on the current level of inventory for each item.

When the amount on hand reaches a predetermined minimum, a fixed quantity, Q, is ordered.

An obvious advantage of this system is the control provided by the continuous monitoring of inventory withdrawals.

Another advantage is the fixed-order quantity; management can determine an optimal order quantity.

Inventory Counting Systems (Contd.)

One disadvantage of this approach is the added cost of record keeping.

Moreover, a physical count of inventories must still be performed periodically to verify records because of possible errors, pilferage, spoilage, and other factors that can reduce inventory effectiveness.

Inventory Counting Systems (Contd.)

Supermarkets, discount stores, and department stores have always been major users of periodic counting systems.

Today, most have switched to computerized checkout systems using a laser scanning device that reads a **universal product code (UPC)**, or bar code, printed on an item tag or on packaging.

A typical grocery product code is illustrated here:

The zero on the left of the bar code identifies this as a grocery item,

the first five numbers (14800) indicate the manufacturer,

the last five numbers (23208) indicate the specific item

Items in small packages, such as candy and gum, use a six-digit number.

Demand Forecasts and Lead-Time Information

Inventories are used to satisfy demand requirements, so it is essential to have reliable estimates of the amount and timing of demand.

Similarly, it is essential to know how long it will take for orders to be delivered.

In addition, managers need to know the extent to which demand and **lead time** ***(the time between submitting an order and receiving it)*** might vary; the greater the potential variability, the greater the need for additional stock to reduce the risk of a shortage between deliveries.

Thus, there is a crucial link between forecasting and inventory management.

Inventory Costs

Four basic costs are associated with inventories:

* Purchase Costs
* Holding Costs
* Ordering Costs
* Shortage Costs

Inventory Costs

* Purchase Costs

Purchase cost is the amount a vendor or supplier pays to buy the inventory.

It can include shipping costs.

Purchase cost is typically the largest of all inventory costs.

Inventory Costs

* Holding Costs (H)

Holding, or carrying, costs relate to physically having items in storage.

Costs include interest, insurance, taxes (in some states), depreciation, obsolescence, deterioration, spoilage, pilferage, breakage, tracking, picking items from inventory, and warehousing costs (heat, light, rent, workers, equipment, security).

They also include opportunity costs associated with having funds that could be used elsewhere tied up in inventory.

Inventory Costs

* Ordering Costs (S)

Ordering costs are the costs of ordering and receiving inventory.

They are the costs that occur with the actual placement of an order.

They include determining how much is needed, preparing invoices, inspecting goods upon arrival for quality and quantity, and moving the goods to temporary storage.

Ordering costs are generally expressed as a fixed dollar amount per order, regardless of order size.

Inventory Costs

* Ordering Costs (S) (Contd.)

When a firm produces its own inventory instead of ordering it from a supplier, machine **setup costs** (e.g., preparing equipment for the job by adjusting the machine, changing cutting tools) are equivalent to ordering costs; that is, they are expressed as fixed charge per production run, regardless of the size of the run.

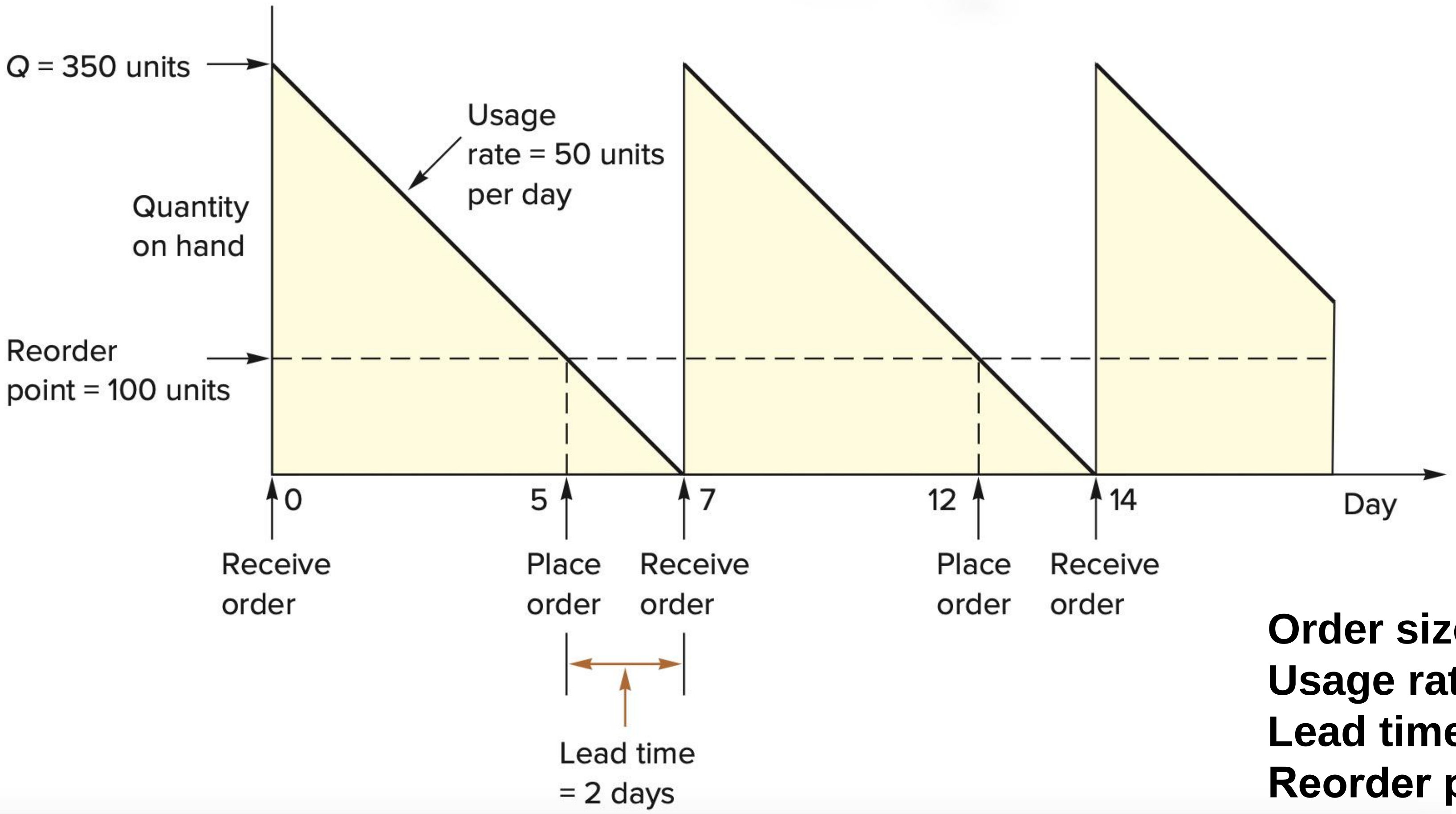
Inventory Costs

* Shortage Costs

Shortage costs result when **demand** exceeds the **supply** of inventory on hand.

These costs can include the opportunity cost of not making a sale, loss of customer goodwill, late charges, backorder costs, and similar costs.

Inventory cycle



Order size, *Q* = 350 units
Usage rate = 50 units per day
Lead time = 2 days
Reorder point = 100 units (2 days' supply)

HOW MUCH TO ORDER: ECONOMIC ORDER QUANTITY MODELS

The question of how much to order can be determined by using an **Economic Order Quantity (EOQ) model**.

EOQ models identify the optimal order quantity by minimizing the sum of certain annual costs that vary with order size and order frequency.

How much quantity to bring in order to have minimum cost?

HOW MUCH TO ORDER:
ECONOMIC ORDER QUANTITY MODELS

EOQ models answer the question of how much to order, but not the question of when to order.

The latter is the function of models that identify the **reorder point (ROP)** in terms of a quantity.

The reorder point occurs when the quantity on hand drops to a predetermined amount and the item is reordered.

Types of inventories

Inventory that is intended to meet expected demand is known as **cycle stock**, while inventory that is held to reduce the probability of experiencing a stockout (i.e., running out of stock) due to demand and/or lead time variability is known as **safety stock**.

The risk of shortages can be reduced by holding **safety stocks**, which are stocks in excess of expected demand to compensate for variabilities in demand and lead time.

Anticipation stocks are those stocks that are held to satisfy expected (i.e., average) demand.

Types of inventories

In addition, intermediate stocking of goods - including raw materials, semifinished items, and finished goods at production sites, as well as goods stored in warehouses - leads to **pipeline inventories** throughout a production-distribution system.

HOW MUCH TO ORDER:
ECONOMIC ORDER QUANTITY MODELS

Reorder point (ROP)

Need to order EOQ at the Reorder Point:

If demand and lead time are both constant,

The reorder point is simply **ROP = d × LT**

Where,

d = Demand Rate (units per day or week)

LT = Lead time in days or weeks

Note: Demand and lead time must be expressed in the same time units.

HOW MUCH TO ORDER: ECONOMIC ORDER QUANTITY MODELS

Reorder point (ROP)

Demand (D) = 10,000 yards/year

Store open 311 days/year

Daily demand (d) = 10,000 / 311 = 32.154 yards/day

Lead time = L = 10 days

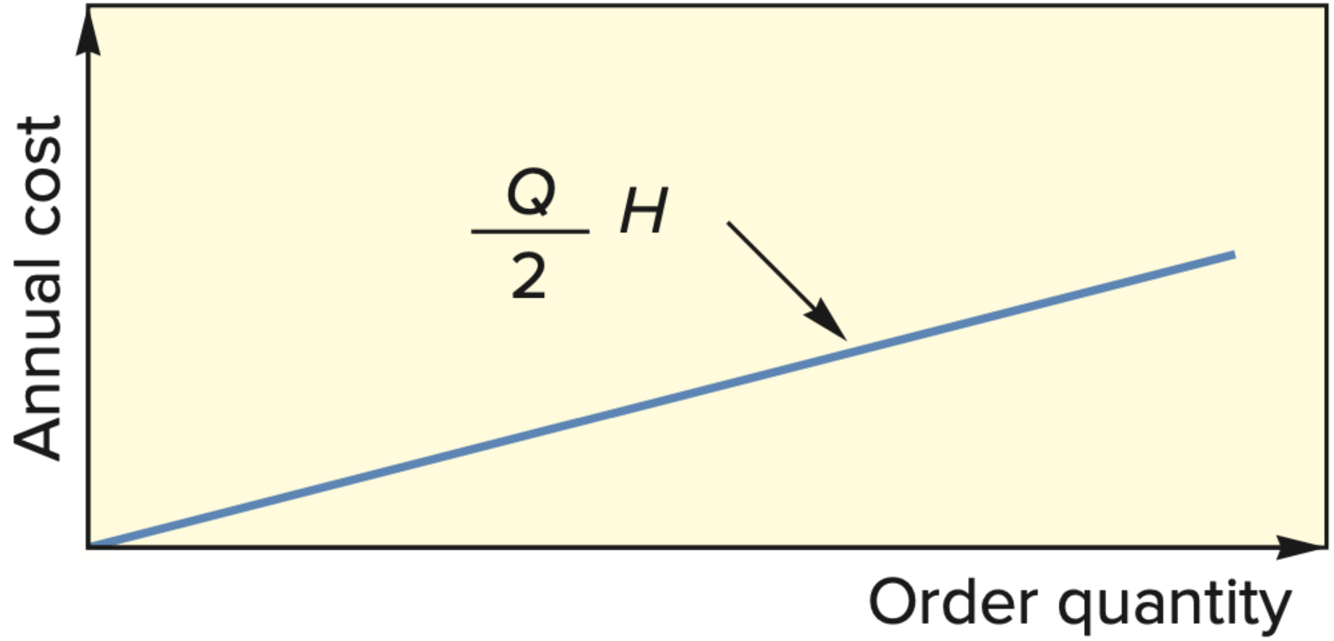
ROP = dL = (32.154)(10) = **321.54 yards**

ECONOMIC ORDER QUANTITY MODELS

Assumptions of the Basic EOQ Model

1. Only one product is involved.
2. Annual demand requirements are known.
3. Demand is spread evenly throughout the year so that the demand rate is reasonably constant.
4. Lead time is known and constant.
5. Each order is received in a single delivery.
6. There are no quantity discounts.

ECONOMIC ORDER QUANTITY MODELS



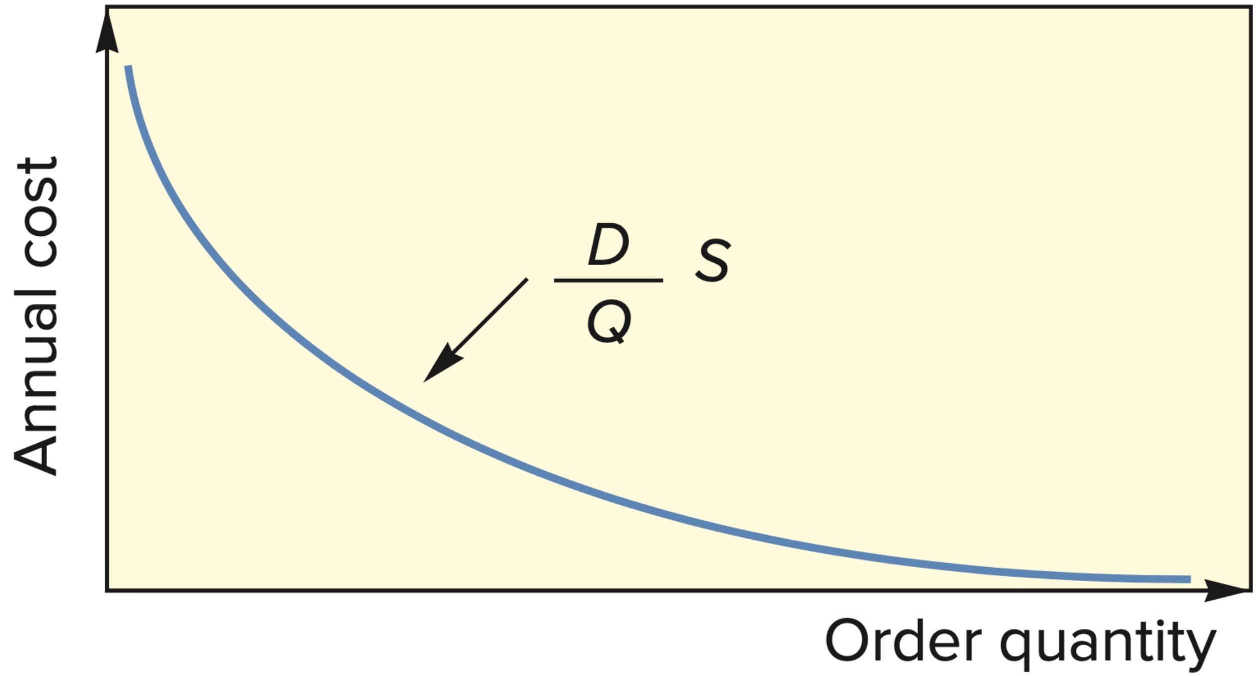
A. Carrying costs are linearly related to order size.

Where,

Q = Order quantity in units
H = Holding (or carrying) cost per unit

Carrying cost is thus a linear function of Q: Carrying costs increase or decrease in direct proportion to changes in the order quantity Q,

ECONOMIC ORDER QUANTITY MODELS



B. Ordering costs are inversely and nonlinearly related to order size.

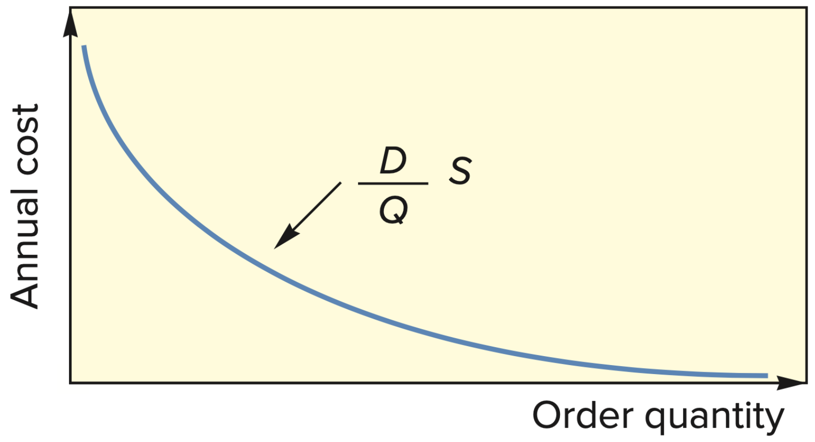
Where,

Q = Order quantity in units

D = Demand, in units per year

S = Ordering cost

ECONOMIC ORDER QUANTITY MODELS



B. Ordering costs are inversely and nonlinearly related to order size.

On the other hand, annual ordering costs will decrease as order size increases because, for a given annual demand, the larger the order size, the fewer the number of orders needed.

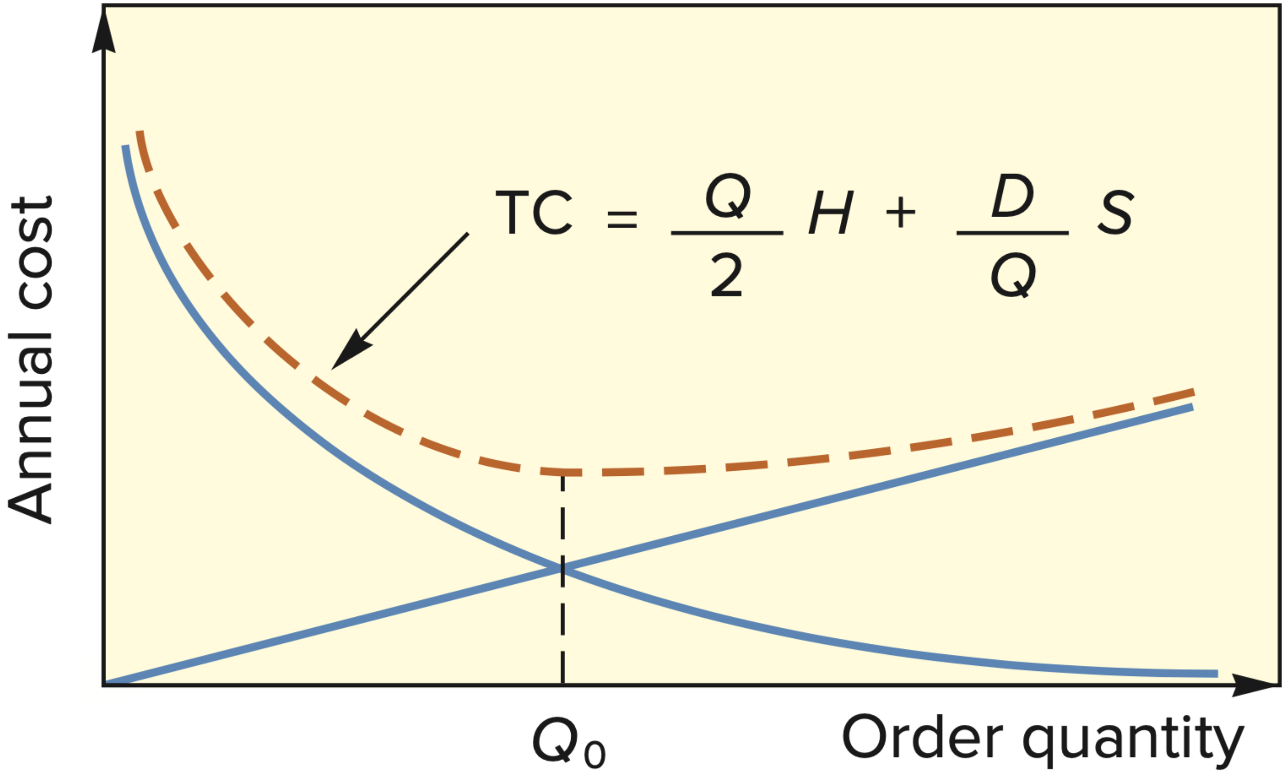
For instance, if the annual demand is 12,000 units and the order size is 1,000 units per order, there must be 12 orders over the year.

But if Q = 2,000 units, only six orders will be needed;

if Q = 3,000 units, only four orders will be needed.

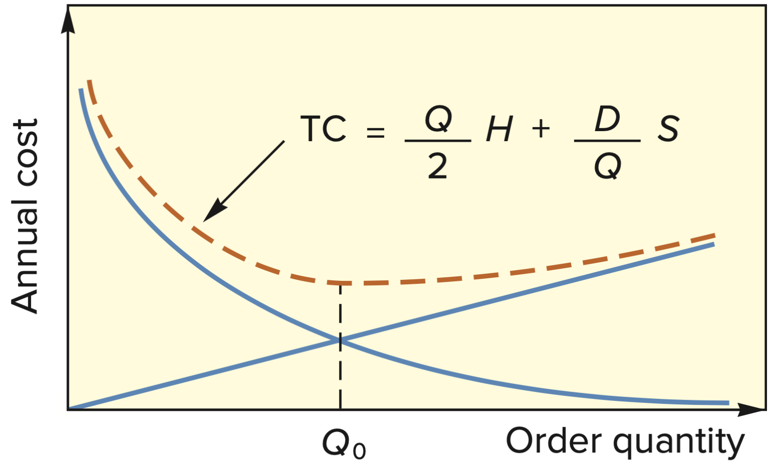
In general, the number of orders per year will be D/Q, where D = Annual demand and Q = Order size.

ECONOMIC ORDER QUANTITY MODELS



C. The total-cost curve is U-shaped.

ECONOMIC ORDER QUANTITY MODELS



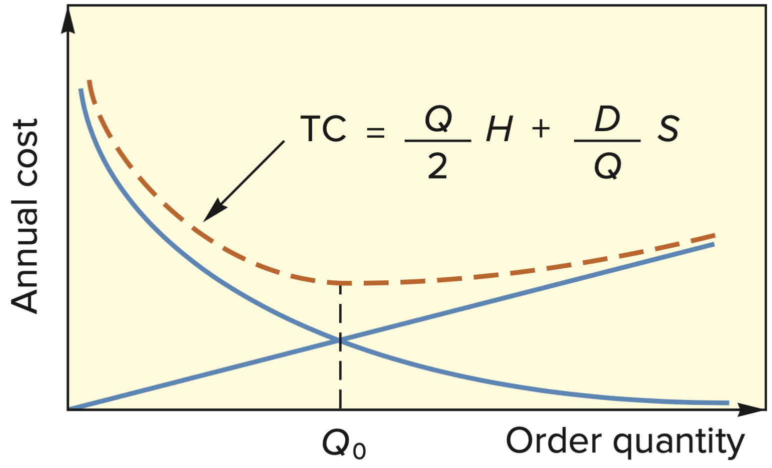
C. The total-cost curve is U-shaped.

The **total annual cost (TC)** associated with carrying and ordering inventory when Q units are ordered each time is

$$TC = \begin{matrix}\text{Annual}\\ \text{carrying}\\ \text{cost}\end{matrix} + \begin{matrix}\text{Annual}\\ \text{ordering}\\ \text{cost}\end{matrix}$$

$$= \frac{Q}{2}H + \frac{D}{Q}S$$

ECONOMIC ORDER QUANTITY MODELS



C. The total-cost curve is U-shaped.

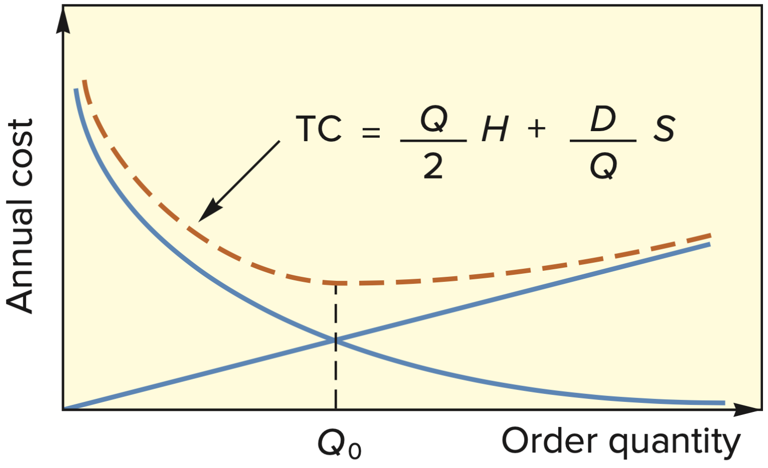
The diagram reveals that the total-cost curve is U-shaped (i.e., convex, with one minimum) and that it reaches its minimum at the quantity where **carrying and ordering costs are equal**.

An expression for the optimal order quantity, Q_0, can be obtained using calculus.

The result is the formula is:

$$\frac{Q}{2}H = \frac{D}{Q}S \quad = Q^2 H = 2DS \qquad Q_0 = \sqrt{\frac{2DS}{H}}$$

ECONOMIC ORDER QUANTITY MODELS



C. The total-cost curve is U-shaped.

Thus, given annual demand, the ordering cost per order, and the annual carrying cost per unit, one can compute the optimal (economic) order quantity.

The minimum total cost is then found by substituting Q_0 for Q.

The length of an order cycle (i.e., the time between orders) is:

$$\text{Length of order cycle} = \frac{Q}{D}$$

ECONOMIC ORDER QUANTITY MODELS

Sample Problem # 1

H = \$0.75 per yard S= \$150 D = 10,000 yards

Lead Time= 7 days

1. What are EOQ and Minimum Total Cost?
2. What is the optimum number of orders per year?
3. What is the length of the order cycle?
4. What is the reorder point?

ECONOMIC ORDER QUANTITY MODELS

Solution# 1

H = $0.75 per yard   *S*= $150   *D* = 10,000 yards   Lead Time= 7 days

1. $EOQ = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2*10000*150}{0.75}}$ = **2000 yards**

2. $TC_{Min} = \frac{EOQ}{2}H + \frac{D}{EOQ}S = \frac{2000}{2}0.75 + \frac{10000}{2000}150$

= 750+750

= **$1500**

ECONOMIC ORDER QUANTITY MODELS

Solution# 1

3. Optimum no. of orders per year = $\frac{D}{EOQ} = \frac{10,000}{2,000} = \mathbf{5\ \mathit{times}}$

4. Length of the Order Cycle = EOQ/ D

$$= \frac{2,000}{10,000} \times 365$$

= **73 days**

ECONOMIC ORDER QUANTITY MODELS

Solution# 1

d = D/365 = 10,000/365 days

= 10,000/365 = **27.40 yards/day**

5. ROP = d×LT

= 27.40 × 7

= **191.80 yards**

ECONOMIC ORDER QUANTITY MODELS

Summary

If my annual requirement is **10,000 yards** at a time, I will place an order of **2,000 yards**.

So that I need to place orders for **5 times** to meet the annual demand of **10,000 yards**.

It will take **73 days** to complete the order of **2,000 yards**.

When I am placing an order of **2,000 yards** at a time, the total cost is minimum at that point and the value will be **$1,500**.

ECONOMIC ORDER QUANTITY MODELS

Summary (Contd.)

Since nothing is mentioned about the total working days/year, so it can be considered that I will be working on 365 days/ year.

So, the daily demand (d) will be **27.40 yards/day**.

Since, the lead time given as 7 days, therefore the Reorder Point (ROP) is **191.80 yards**.

ECONOMIC ORDER QUANTITY MODELS

Sample Problem# 2

Computing and Using the EOQ

A local distributor for a national tire company expects to sell approximately 9,600 steel-belted radial tires of a certain size and tread design next year. Annual carrying cost is $16 per tire, and ordering cost is $75. The distributor operates 288 days a year.

a. What is the EOQ?

b. How many times per year does the store reorder?

c. What is the length of an order cycle?

d. What will the total annual cost be if the EOQ quantity is ordered?

ECONOMIC ORDER QUANTITY MODELS

Solution# 2

$D = 9{,}600$ tires per year
$H = \$16$ per unit per year
$S = \$75$

a. $$Q_0 = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(9{,}600)75}{16}} = 300 \text{ tires.}$$

b. Number of orders per year: $D/Q = \dfrac{9{,}600 \text{ tires/year}}{300 \text{ tires/order}} = 32$ orders.

c. Length of order cycle: Q/D $= \dfrac{300 \text{ tires}}{9{,}600 \text{ tires/year}} = \frac{1}{32}$ of a year, which is $\frac{1}{32} \times 288$, or 9 workdays.

d. $$\begin{aligned} \text{TC} &= \text{Carrying cost} + \text{Ordering to} \\ &= (Q/2)H + (D/Q)S \\ &= (300/2)16 + (9{,}600/300)75 \\ &= \$2{,}400 + \$2{,}400 \\ &= \$4{,}800 \end{aligned}$$

ECONOMIC ORDER QUANTITY MODELS

Sample Problem# 3

Computing the EOQ

Piddling Manufacturing assembles security systems. It purchases 3,600 high-definition security cameras a year at $180 each. Ordering costs are $50, and annual carrying costs are 20 percent of the purchase price. Compute the optimal quantity and the total annual cost of ordering and carrying the inventory.

SOLUTION

D = 3,600 security cameras per year

S = \$50

H = .20(\$180) = \$36

$$Q_0 = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(3{,}600)(50)}{36}} = 100 \text{ security cameras}$$

$$\begin{aligned} \text{TC} &= \text{Carrying costs} + \text{Ordering costs} \\ &= (Q_0/2)H + (D/Q_0)S \\ &= (100/2)36 + (3{,}600/100)50 \\ &= \$1{,}800 + \$1{,}800 = \$3{,}600 \end{aligned}$$

ECONOMIC ORDER QUANTITY MODELS

Sample Problem# 4

One of the top-selling items in the container group at a museum's gift shop is a bird feeder. Sales are 18 units per week and the supplier charges Tk. 60 per unit. The cost of placing an order is Tk. 45/-. The annual holding cost is 25% of a feeder's value and the museum operates 52 weeks per year. Management choose a 390 units lot size so that new orders could be placed less frequently.

1. Identify EOQ.
2. Determine the annual cost of the current lot size of 390 units.
3. Determine the annual cost considering the EOQ.

ECONOMIC ORDER QUANTITY MODELS

Solution# 4

Parameters:

Q = 390 units

D = 18 × 52 = 936 units

Ordering Cost = S = Tk. 45/-

Holding Cost = H = Tk. 60 *25% = Tk. 15/-

1. $EOQ = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2*936*45}{15}} = \mathbf{75\ units}$

ECONOMIC ORDER QUANTITY MODELS

Solution# 4

Parameters:

Q = 390 units

D = 18 × 52 = 936 units

Ordering Cost = S = Tk. 45/-

Holding Cost = H = Tk. 60 *25% = Tk. 15/-

Annual Cost (when Q = 390 units)

Number of orders per year = D/Q = 936/390 = **2.4 orders**

Annual Holding Cost = (Q/2) × H = (390/2) × 15 = **Tk. 2925/-**

Annual Ordering Cost = (D/Q) × S = (936/390) × 45 = **Tk. 108/-**

Annual Inventory Cost = 2925 + 108 = **Tk. 3,033/-**

ECONOMIC ORDER QUANTITY MODELS

Solution# 4

Parameters:

Q = 390 units

D = 18 × 52 = 936 units

Ordering Cost = S = Tk. 45/-

Holding Cost = H = Tk. 60 *25% = Tk. 15/-

Annual Cost (when Q = EOQ = 75 units)

Number of orders per year = D/EOQ = 936/75 = **12.48 orders**

Annual Holding Cost = (EOQ/2) × H = (75/2) × 15 = **Tk. 562.50/-**

Annual Ordering Cost = (D/EOQ) × S = (936/75) × 45 = **Tk. 561.60/-**

Annual Inventory Cost = 562.50 + 561.60 = **Tk. 1,124.10/-**

ECONOMIC ORDER QUANTITY MODELS

Sample Problem# 5

One of the top-selling items in the container group at a museum’s gift shop is a bird feeder. Sales are 29 units per week and the supplier charges Tk. 60/- per unit.

The cost of placing an order is Tk. 65/-. The annual holding cost is 15% of a feeder’s value and the museum operates 52 weeks per year. Management chose a 490 units lot size so that new orders could be placed less frequently.

1. Identify EOQ.
2. Determine the annual cost of the current lot size of 490 units.
3. Determine the annual cost considering the EOQ.

END OF THE CHAPTER