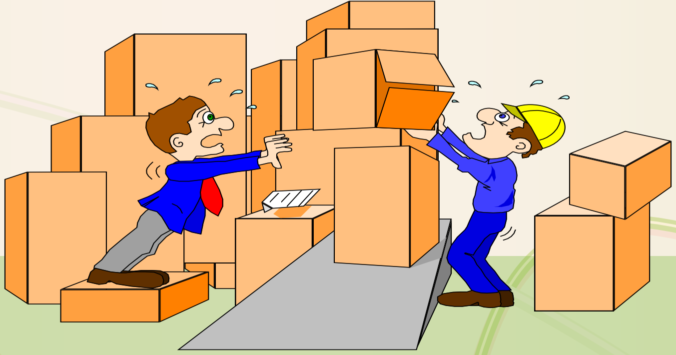


INVENTORY MANAGEMENT

OVERVIEW

- Introduction
- Objectives
- Opposing Views of Inventory
- Nature of Inventory
- Factors Affecting Inventory
- Costs in Inventory
- Inventory Categories - Special Considerations

Overview (Cont’d)

- Departments of Inventory Management
- Functions of Inventory
- Selective Inventory Control
- Reorder Quantity Methods And EOQ
- Reorder Time Methods
- References

INTRODUCTION

INTRODUCTION

Definition:

Scientific method of finding out **how much** stock should be maintained in order to meet the production demands and be able to provide right type of material at right time, in right quantities and at competitive prices.

Introduction (Cont'd)

- *Inventory is actually* *money*, which is available in the shape of materials (raw materials, in-process and finished products), equipment, storage space, work-time etc.

Input
Material Management department

→

Inventory (money)
Goods in stores
Work-in-progress
Finished products
Equipment etc.

→

Output
Production department

Basic inventory model

Introduction (Cont'd)

- Inventory control is concerned with achieving an optimum balance between two competing objectives.

1) Minimizing the investment in inventory.
2) Maximizing the service levels to customer's and it's operating departments.

OBJECTIVES

OBJECTIVES

- The specific objectives of inventory management are as follow:

a) Utilizing of scare resources (capital) and investment judiciously.

b) Keeping the production on as on-going basis.

c) Preventing idleness of men, machine and morale.

Objectives (Cont’d)

d) Avoiding risk of loss of life (moral & social).

e) Reducing administrative workload.

f) Giving satisfaction to customers in terms of quality-care, competitive price and prompt delivery.

g) Inducing confidence in customers and to create trust and faith.

OPPOSING VIEWS OF INVENTORY

- Why We Want to Hold Inventories?
- Why We Do Not Want to Hold Inventories?

Why We Want to Hold Inventories?

- Improve customer service.
- Reduce certain costs such as
  - ordering costs
  - stock out costs
  - acquisition costs
  - start-up quality costs
- Contribute to the efficient and effective operation of the production system.

Why We Want to Hold Inventories?

- Finished Goods
  - Essential in produce-to-stock positioning strategies
  - Necessary in level aggregate capacity plans
  - Products can be displayed to customers
- Work-in-Process
  - Necessary in process-focused production
  - May reduce material-handling & production costs
- Raw Material
  - Suppliers may produce/ship materials in batches
  - Quantity discounts and freight/handling, $$ savings

Why We Do Not Want to Hold Inventories?

- Certain costs increase such as
  - – carrying costs
  - – cost of customer responsiveness
  - – cost of coordinating production
  - – cost of diluted return on investment
  - – reduced-capacity costs
  - – large-lot quality cost
  - – cost of production problems

NATURE OF INVENTORY

NATURE OF INVENTORY

- Two Fundamental Inventory Decisions
- Independent Demand Inventory Systems
- Dependent Demand Inventory Systems
- Inventory Costs

Two Fundamental Inventory Decisions

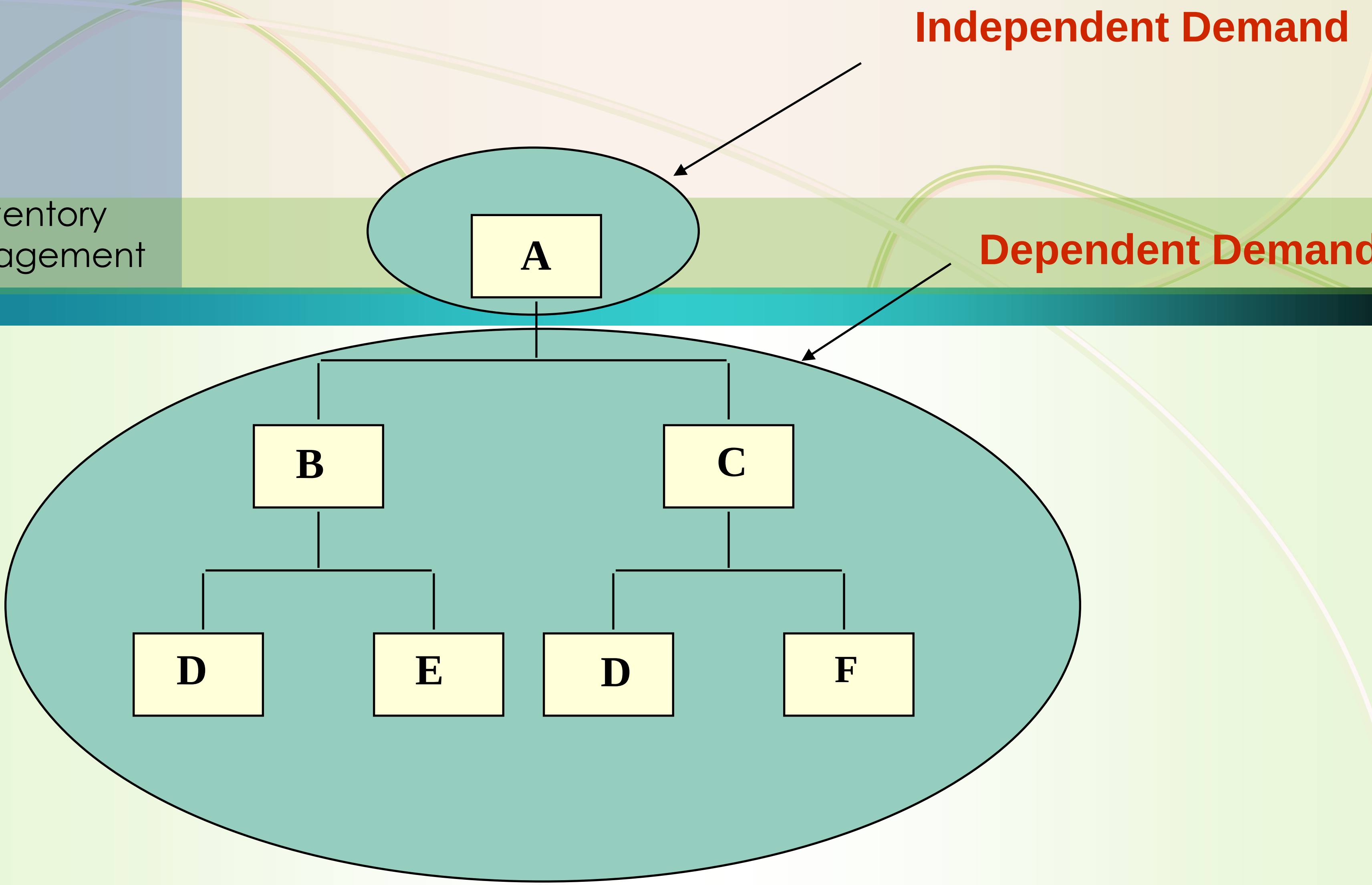
- **How much** to order of each material?
- **When** to place the orders?

Independent Demand Inventory Systems

- Demand for an item is independent of the demand for any other item in inventory.
- Finished goods inventory is an example.
- Demands are estimated from forecasts and/or customer orders.

Dependent Demand Inventory Systems

- Demand of item depends on the demands for other items.
- For example, the demand for raw materials and components.
- The systems used to manage these inventories are different.



Independent demand is uncertain.
Dependent demand is certain.

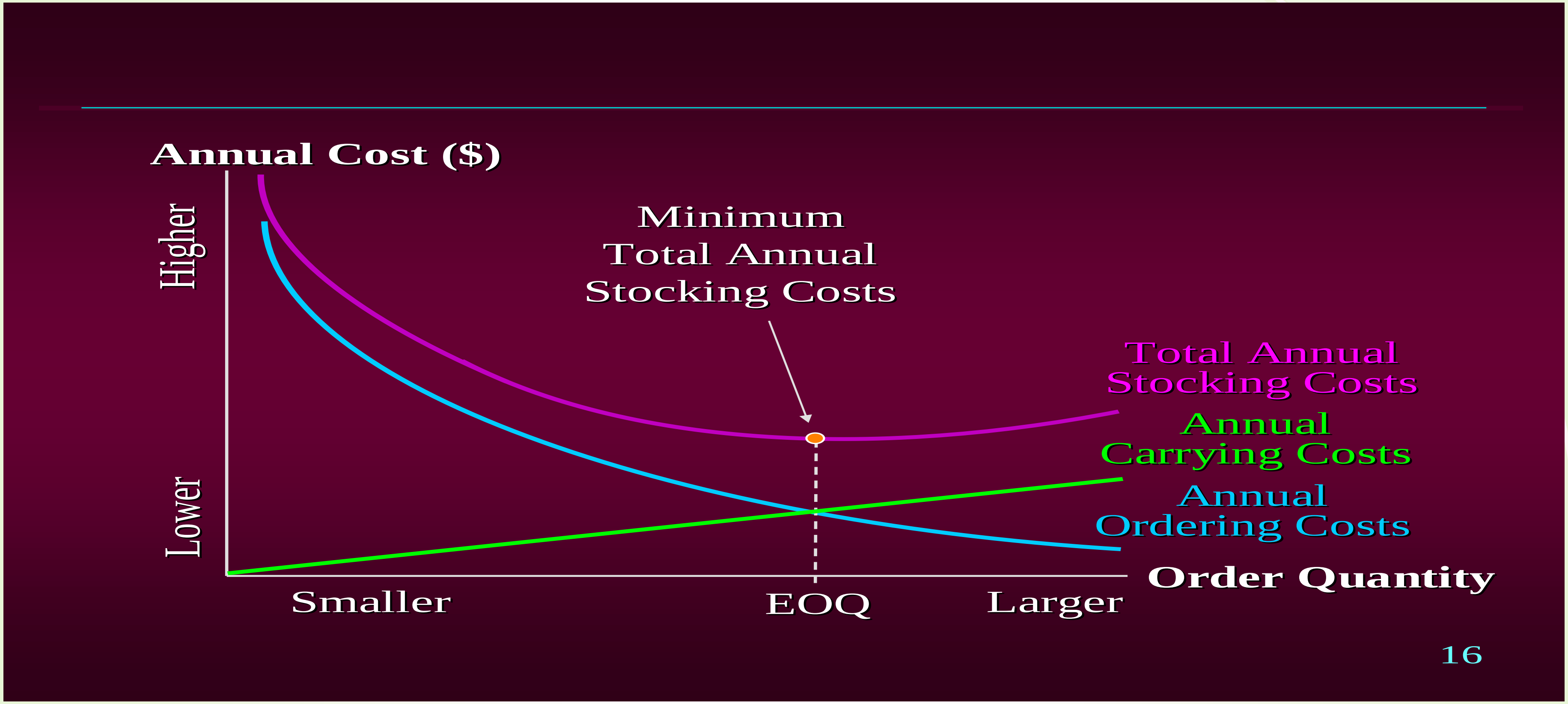
Inventory Costs

- Costs associated with ordering too much (represented by carrying costs).
- Costs associated with ordering too little (represented by ordering costs).
- These costs are opposing costs, i.e., as one increases the other decreases.

Inventory Costs (continued)

- The sum of the two costs is the total stocking cost (TSC).
- **When plotted against order quantity, the TSC decreases to a minimum cost and then increases**.
- This cost behavior is the basis for answering the first fundamental question: how much to order.

Balancing Carrying against Ordering Costs



FACTORS AFFECTING INVENTORY

FACTORS INFLUENCING INVENTORY

- Manufacture requires relatively long process cycle-time.
- Procurement of materials has a long lead-time.
- Demand for finished products is sometimes seasonal and prone fluctuation.
- Material costs are affected by fluctuations in demand and subsequently by fluctuations in manufacturing.

COSTS IN INVENTORY

COSTS IN INVENTORY

Inventory costs may vary from 28 to 32% of the total cost. Apart from material costs, several other costs are also involved in inventory. These are given as below:

- Ordering Costs
- Holding Costs/ Carrying Costs
- Stock Out Costs

Ordering Costs

- Stationary
- Clerical and processing, salaries/rentals
- Postage
- Processing of bills
- Staff work in expedition /receiving/ inspection and documentation

Holding/Carrying Costs

- Storage space (rent/depreciation)
- Property tax on warehousing
- Insurance
- Deterioration/Obsolescence
- Material handling and maintenance, equipment
- Stock taking, security and documentation
- Capital blocked (interest/opportunity cost)
- Quality control

Stock out Costs

- Loss of business/ profit/ market/ advise
- Additional expenditure due to urgency of purchases

  a) telegraph / telephone charges

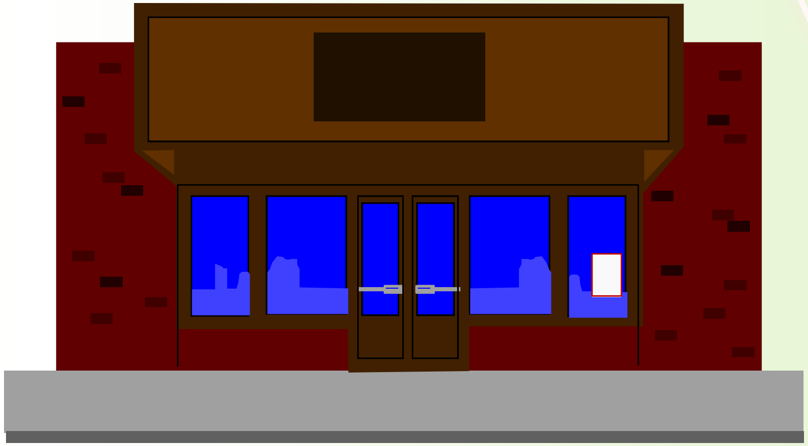
  b) purchase at premium

  c) air transport charges
- Loss of labor hours

INVENTORY CATEGORIES – SPECIAL CONSIDERATION

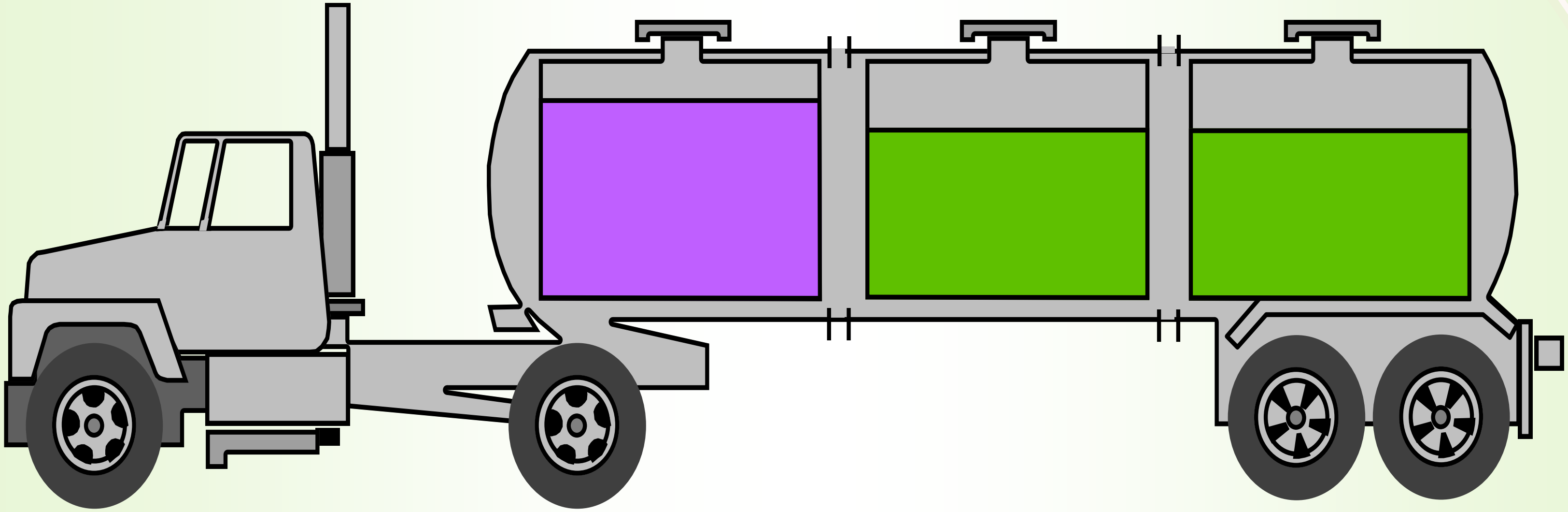
INVENTORY CATEGORIES – SPECIAL CONSIDERATIONS

- Raw materials & purchased parts
- Partially completed goods called *work in progress*
- Finished-goods inventories
  - (*manufacturing firms*) or merchandise (*retail stores*)

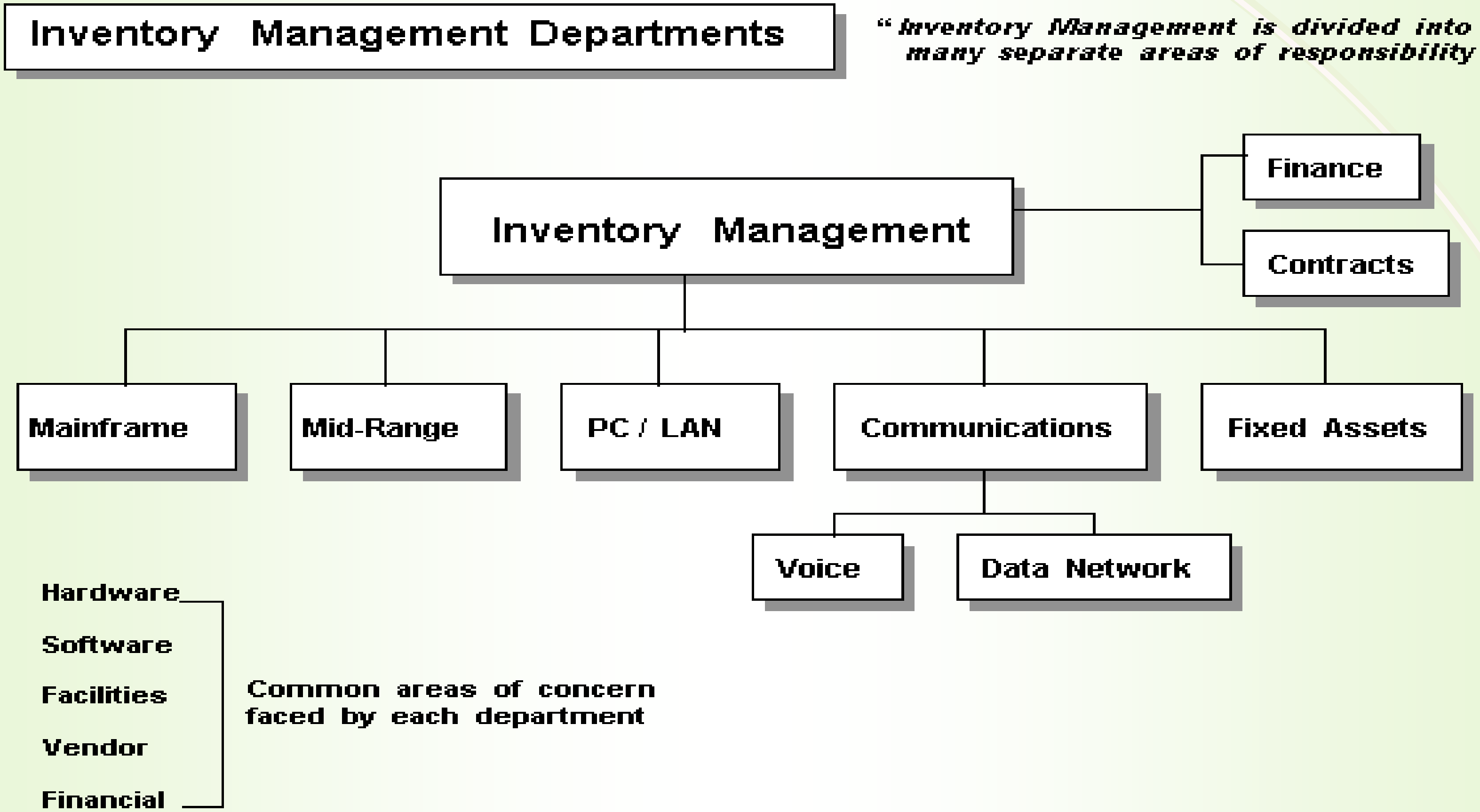


INVENTORY CATEGORIES – SPECIAL CONSIDERATIONS

- Replacement parts, tools, & supplies
- Goods-in-transit to warehouses or customers



Departments of Inventory Management



FUNCTIONS OF INVENTORY

KLE UNIVERSITY
EMPOWERING PROFESSIONALS

Inventory Optimization

- evaluate your inentory
- recommend safety stock
- cross plant rationalization
- eliminate duplication and standardized materials of construction

Inventory Process Improvement

- automate replacement process
- integrate planned repair schedules

Population Survey

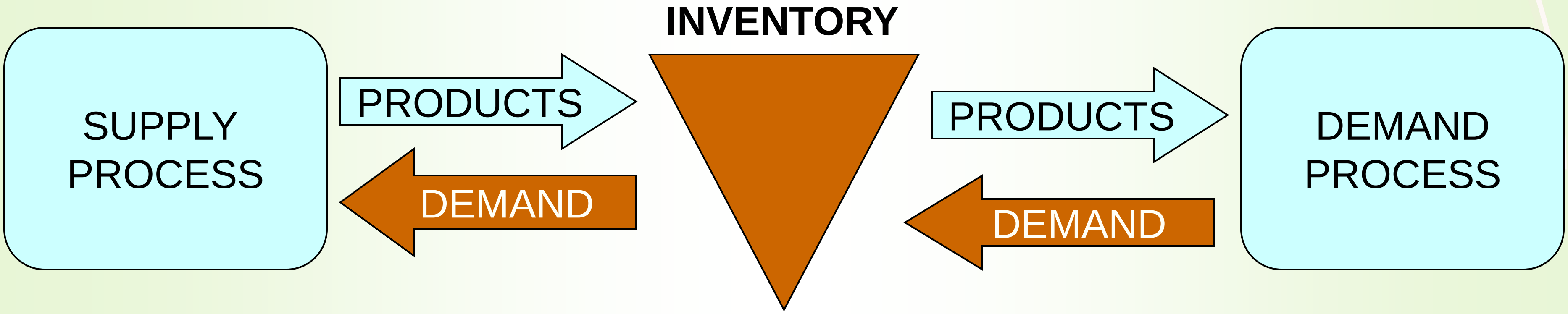
- recommend sub assemblies to eliminate costly multiple levels of inventory
- identify upgrade opportunities
- power end exchange program
- identify obsolete inventory
- recommend material reationalization

Excess Inventory Disposition

- use in PRO Shop repairs or for credit
- remarketing to other ITT Industries customers

FUNCTIONS OF INVENTORY

- To meet anticipated demand.
- To smoothen production requirements.
- To decouple operations.



Functions Of Inventory (Cont'd)

- To protect against stock-outs.
- To take advantage of order cycles.
- To help hedge against price increases.
- To permit operations.
- To take advantage of quantity discounts.

SELECTIVE INVENTORY CONTROL

SELECTIVE INVENTORY CONTROL

- ***Selective Inventory Control*** is defined as a process of classifying items into different categories, thereby directing appropriate attention to the materials in the context of company's viability.

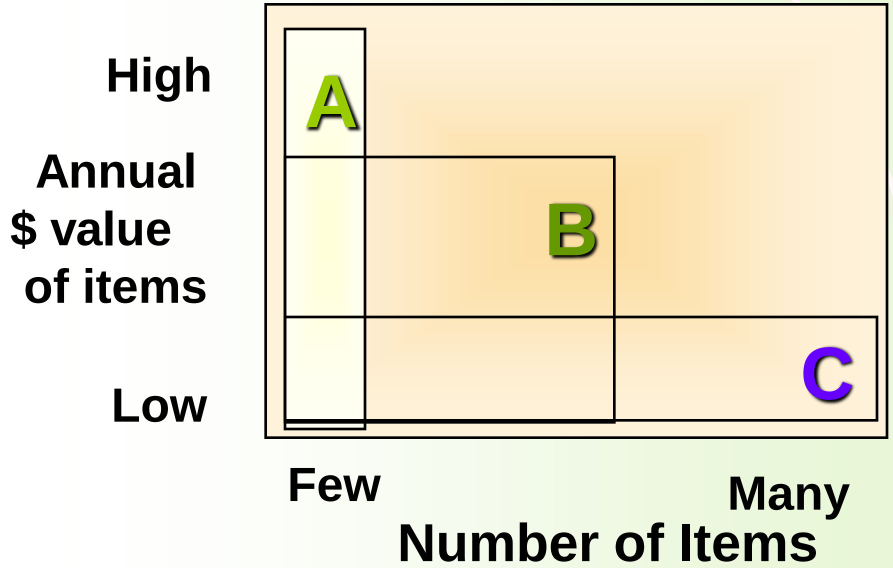
Classification of Materials for Inventory Control

Classification	*Criteria*
A-B-C	Annual value of consumption of the items
V-E-D	Critical nature of the components with respect to products.
H-M-L	Unit price of material
F-S-N	Issue from stores
S-D-E	Purchasing problems in regard to availability
S-O-S	Seasonality
G-O-L-F	Channel for procuring the material
X-Y-Z	Inventory value of items stored

ABC Classification System

Classifying inventory according to annual value of consumption of the items.

- **A** - very important
- **B** - mod. important
- **C** - least important



ABC Classification System (Cont'd)

- When a large number of items are involved, relatively few items account for a major part of activity, based on annual value of consumption of items.
- It is based on the principles of '*vital few and trivial many*'.

ABC Classification System (Cont'd)

- ***A-items*** : 15% of the items are of the highest value and their inventory accounts for 70% of the total.
- ***B-items*** : 20% of the items are of the intermediate value and their inventory accounts for 20% of the total.
- ***C-items*** : 65%(remaining) of the items are lowest value and their inventory accounts for the relatively small balance, i.e., 10%.

Procedure for classification

- All items used in an industry are identified.
- All items are listed as per their value.
- The number of items are counted and categorized as high-, medium- and low-value.
- The percentage of high-, medium- and low- valued items are determined.

Inventory Counting Systems

- ***<u>Periodic System</u>***

  Physical count of items made at periodic intervals.

- ***<u>Perpetual Inventory System</u>***

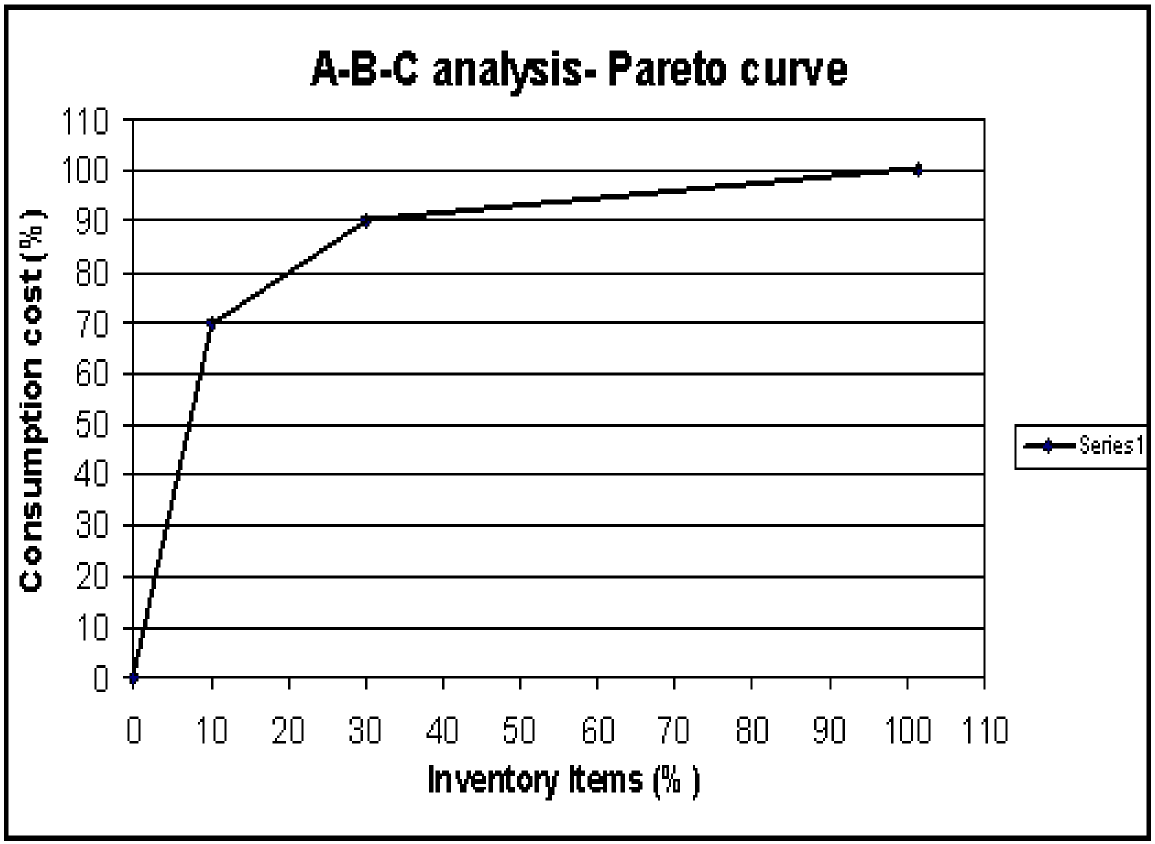
  System that keeps track of removals from inventory continuously, thus monitoring current levels of each item.

Inventory Counting Systems (Cont'd)

- ***Two-Bin System*** - Two containers of inventory; reorder when the first is empty.
- ***Universal Bar Code*** - Bar code printed on a label that has information about the item to which it is attached.

214800 232087768

Pareto curve



V-E-D Classification

- Based on the critical nature of items.
- Applicable to spare parts of equipment, as they do not follow a predictable demand pattern.
- Very important in hospital pharmacy.

V-E-D Classification (Cont'd)

- **V**-Vital : Items without which the activities will come to a halt.
- **E**-Essential : Items which are likely to cause disruption of the normal activity.
- **D**-Desirable : In the absence of which the hospital work does not get hampered.

H-M-L Classification

- Based on the unit value (in rupees) of items.
- Similar to A-B-C analysis

H-High

M-Medium

L -Low

F-S-N Classification

- Takes into account the distribution and handling patterns of items from stores.
- Important when obsolescence is to be controlled.

F – Fast moving
S – Slow moving
N – Non moving

S-D-E Classification

- Based on the lead-time analysis and availability.

    S – Scarce : longer lead time

    D – Difficult : long lead time

    E – Easy : reasonable lead time

S-O-S Classification

- **S-O-S :Seasonal- Off- Seasonal**
- Some items are seasonal in nature and hence require special purchasing and stocking strategies.
- EOQ formula cannot be applied in these cases.
- Inventories at the time of procurement will be extremely high.

G-O-L-F Classification

- G-O-L-F stands for:

G – Government

O – Ordinary

L – Local

F – Foreign

X-Y-Z Classification

- Based on the value of inventory stored.
- If the values are high, special efforts should be made to reduce them.
- This exercise can be done once a year.

REORDER QUANTITY METHODS AND EOQ

Reorder Quantity Methods

- Reorder Quantity is the quantity of items to be ordered so as to continue production without any interruptions in the future.

- Some of the methods employed in the calculation of reorder quantity are described below:

Reorder Quantity Methods (Cont'd)

- Fixed Quantity System
- Open access bin system
- Two-bin system

Fixed Quantity System

- The reorder quantity is a fixed one.
- Time for order varies.
- When stock level drops to reorder level, then order is placed.
- Calculated using EOQ formula.

Reorder level quantity (ROL or reorder point)= safety stock + (usage rate + lead-time)

Open access bin system

- Bin is filled with items to maximum level.
- Open bins are kept at places nearer to the production lines.
- Operators use items without making a record.
- Items are replenished at fixed timings.
- This system is used for nuts and bolts.
- Eliminates unnecessary paper work and saves time.

Two-bin system

- Two bins are kept having items at different level.

- When first bin is exhausted, it indicates reorder.

- Second bin is a reserve stock and used during lead-time period.

EOQ

What is EOQ?

EOQ = mathematical device for arriving at the purchase quantity of an item that will minimize the cost.

total cost = holding costs + ordering costs

EOQ (Cont'd)

So…What does that mean?

Basically, EOQ helps you identify the most economical way to replenish your inventory by showing you the best order quantity.

EOQ System

- Behavior of Economic Order Quantity (EOQ) Systems
- Determining Order Quantities
- Determining Order Points

Behavior of EOQ Systems

- As demand for the inventoried item occurs, the inventory level drops.
- When the inventory level drops to a critical point, the order point, the ordering process is triggered.
- The amount ordered each time an order is placed is fixed or constant.

Behavior of EOQ Systems

- When the ordered quantity is received, the inventory level increases.
- An application of this type system is the two-bin system.
- A perpetual inventory accounting system is usually associated with this type of system.

Determining Order Quantities

- Basic EOQ
- EOQ for Production Lots
- EOQ with Quantity Discounts

Model I: Basic EOQ

Typical assumptions made

- Only one product is involved.
- Annual demand requirements known.
- Demand is even throughout the year.
- Lead time does not vary.
- Each order is received in a single delivery.
- There are no quantity discounts.

Assumptions

- Annual demand (D), carrying cost (C) and ordering cost (S) can be estimated.

- Average inventory level is the fixed order quantity (Q) divided by 2 which implies
  - no safety stock
  - orders are received all at once

Assumptions

- demand occurs at a uniform rate
- no inventory when an order arrives
- stock-out, customer responsiveness, and other costs are inconsequential
- acquisition cost is fixed, i.e., no quantity discounts

Assumptions

- Annual carrying cost = (average inventory level) x (carrying cost) = (Q/2)C

- Annual ordering cost = (average number of orders per year) x (ordering cost) = (D/Q)S

Total Cost

$$\text{Total cost} = \begin{array}{l}\text{Annual}\\ \text{carrying}\\ \text{cost}\end{array} + \begin{array}{l}\text{Annual}\\ \text{ordering}\\ \text{cost}\end{array}$$

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

EOQ Equation

- Total annual stocking cost (TSC) = annual carrying cost + annual ordering cost = (Q/2)C + (D/Q)S
- The order quantity where the TSC is at a minimum (EOQ) can be found using calculus (take the first derivative, set it equal to zero and solve for Q)

How does it work?

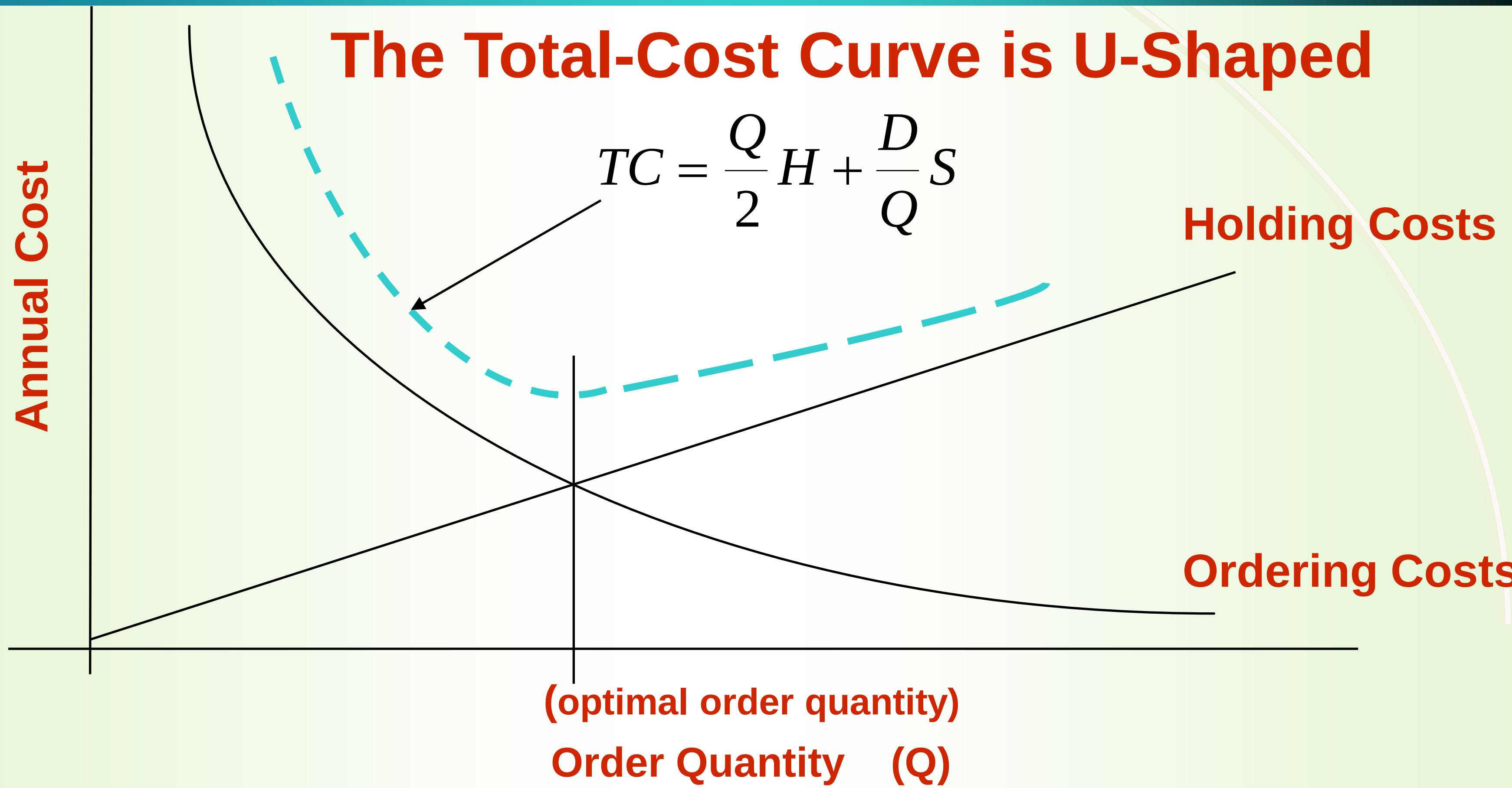
- Total annual holding cost = (Q/2)H
- Total annual ordering cost = (D/Q)S
- EOQ:
  - Set (Q/2)H = (D/Q)S and solve for Q

Solve for Q algebraically

- $(Q/2)H = (D/Q)S$
- $Q^2 = 2DS/H$
- Q = **square root of** (2DS/H) = EOQ

$$Q_{OPT} = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(\text{Annual Demand})(\text{Order or Setup Cost})}{\text{Annual Holding Cost}}}$$

Cost Minimization Goal



Minimum Total Cost

- The total cost curve reaches its minimum where the carrying and ordering costs are equal.

Definition of EOQ Components

H = annual holding cost for one unit of inventory

S = cost of placing an order, regardless of size

P = price per unit

d = demand per period

D = annual demand

L = lead time

Q = Order quantity (this is what we are solving for)

Example: Basic EOQ

- Zartex Co. produces fertilizer to sell to wholesalers. One raw material – calcium nitrate – is purchased from a nearby supplier at $22.50 per ton. Zartex estimates it will need 5,750,000 tons of calcium nitrate next year.
- The annual carrying cost for this material is 40% of the acquisition cost, and the ordering cost is $595.

Example: Basic EOQ

a) What is the most economical order quantity?

b) How many orders will be placed per year?

c) How much time will elapse between orders?

Example: Basic EOQ

- Economical Order Quantity (EOQ)

  D = 5,750,000 tons/year

  C = .40(22.50) = $9.00/ton/year

  S = $595/order

$$EOQ = \sqrt{2DS/C}$$

$$EOQ = \sqrt{2(5,750,000)(595)/9.00}$$

= 27,573.135 tons per order

Example: Basic EOQ

- Total Annual Stocking Cost (TSC)

$$TSC = (Q/2)C + (D/Q)S$$

$$= (27{,}573.135/2)(9.00)$$

$$+ (5{,}750{,}000/27{,}573.135)(595)$$

$$= 124{,}079.11 + 124{,}079.11$$

$$= \$248{,}158.22$$

Note: Total Carrying Cost equals Total Ordering Cost

Example: Basic EOQ

- Number of Orders Per Year

  = D/Q

  = 5,750,000/27,573.135

  = 208.5 orders/year

- Time Between Orders

  = Q/D

  = 1/208.5

  = .004796 years/order

  = .004796(365 days/year) = 1.75 days/order

Note: This is the inverse of the formula above.

Model II: EOQ for Production Lots

- Used to determine the order size, production lot.

- Differs from Model I because orders are assumed to be supplied or produced at a uniform rate (p) rather than the order being received all at once.

Model II: EOQ for Production Lots

- It is also assumed that the supply rate, p, is greater than the demand rate, d
- The change in maximum inventory level requires modification of the TSC equation
- TSC = (Q/2)[(p-d)/p]C + (D/Q)S
- The optimization results in

$$EOQ = \sqrt{\frac{2DS}{C}\left[\frac{p}{p-d}\right]}$$

Example: EOQ for Production Lots

- Highland Electric Co. buys coal from Cedar Creek Coal Co. to generate electricity. CCCC can supply coal at the rate of 3,500 tons per day for $10.50 per ton. HEC uses the coal at a rate of 800 tons per day and operates 365 days per year.

Example: EOQ for Production Lots

- HEC's annual carrying cost for coal is 20% of the acquisition cost, and the ordering cost is $5,000.

a) What is the economical production lot size?

b) What is HEC's maximum inventory level for coal?

Example: EOQ for Production Lots

Economical Production Lot Size

d = 800 tons/day; D = 365(800) = 292,000tons/year

p = 3,500 tons/day

S = $5,000/order., C = .20(10.50)= $2.10/ton/year

$$EOQ = \sqrt{(2DS/C)[p/(p-d)]}$$

$$EOQ = \sqrt{2(292{,}000)(5{,}000)/2.10[3{,}500/(3{,}500-800)]}$$

= 42,455.5 tons per order

Example: EOQ for Production Lots

- Total Annual Stocking Cost (TSC)

TSC = (Q/2)((p-d)/p)C + (D/Q)S

= (42,455.5/2)((3,500-800)/3,500)(2.10)

+ (292,000/42,455.5)(5,000)

= 34,388.95 + 34,388.95

= $68,777.90

Note: Total Carrying Cost equals Total Ordering Cost

Model III: EOQ with Quantity Discounts

- Lower unit price on larger quantities ordered.
- This is presented as a price or discount schedule, i.e., a certain unit price over a certain order quantity range
- This model differs from Model I because the acquisition cost (ac) may vary with the quantity ordered, i.e., it is not necessarily constant.

Model III: EOQ with Quantity Discounts

- Under this condition, acquisition cost becomes an incremental cost and must be considered in the determination of the EOQ
- The total annual material costs (TMC) = Total annual stocking costs (TSC) + annual acquisition cost

TSC = (Q/2)C + (D/Q)S + (D)ac

Model III: EOQ with Quantity Discounts

To find the EOQ, the following procedure is used:

1. Compute the EOQ using the lowest acquisition cost.

- If the resulting EOQ is feasible (the quantity can be purchased at the acquisition cost used), this quantity is optimal and you are finished.
- If the resulting EOQ is not feasible, go to Step 2

2. Identify the next higher acquisition cost.

Model III: EOQ with Quantity Discounts

3. Compute the EOQ using the acquisition cost from Step 2.

- If the resulting EOQ is feasible, go to Step 4.
- Otherwise, go to Step 2.

4. Compute the TMC for the feasible EOQ (just found in Step 3) and its corresponding acquisition cost.

5. Compute the TMC for each of the lower acquisition costs using the minimum allowed order quantity for each cost.

6. The quantity with the lowest TMC is optimal.

Example: EOQ with Quantity Discounts

A-1 Auto Parts has a regional tyre warehouse in Atlanta. One popular tyre, the XRX75, has estimated demand of 25,000 next year. It costs A-1 $100 to place an order for the tyres, and the annual carrying cost is 30% of the acquisition cost. The supplier quotes these prices for the tire:

Q	ac
1 – 499	$21.60
500 – 999	20.95
1,000 +	20.90

Example: EOQ with Quantity Discounts

- Economical Order Quantity

$$EOQ_i = \sqrt{2DS/C_i}$$

$$EOQ_3 = \sqrt{2(25{,}000)100/(.3(20.90)} = 893.00$$

This quantity is not feasible, so try ac = $20.95

$$EOQ_2 = \sqrt{2(25{,}000)100/(.3(20.95)} = 891.93$$

This quantity is feasible, so there is no reason to try ac = $21.60

Example: EOQ with Quantity Discounts

- Compare Total Annual Material Costs (TMCs)

$$TMC = (Q/2)C + (D/Q)S + (D)ac$$

Compute TMC for **Q** = 891.93 and **ac** = $20.95

$$
\begin{aligned}
TMC2 &= (891.93/2)(.3)(20.95) + (25{,}000/891.93)100 \\
&\quad + (25{,}000)20.95 \\
&= 2{,}802.89 + 2{,}802.91 + 523{,}750 \\
&= \$529{,}355.80
\end{aligned}
$$

Example: EOQ with Quantity Discounts

Compute TMC for Q = 1,000 and ac = $20.90

TMC3 = (1,000/2)(.3)(20.90) +(25,000/1,000)100
+ (25,000)20.90
= 3,135.00 + 2,500.00 + 522,500
= $528,135.00 (lower than TMC2)

The EOQ is 1,000 tyres
at an acquisition cost of $20.90.

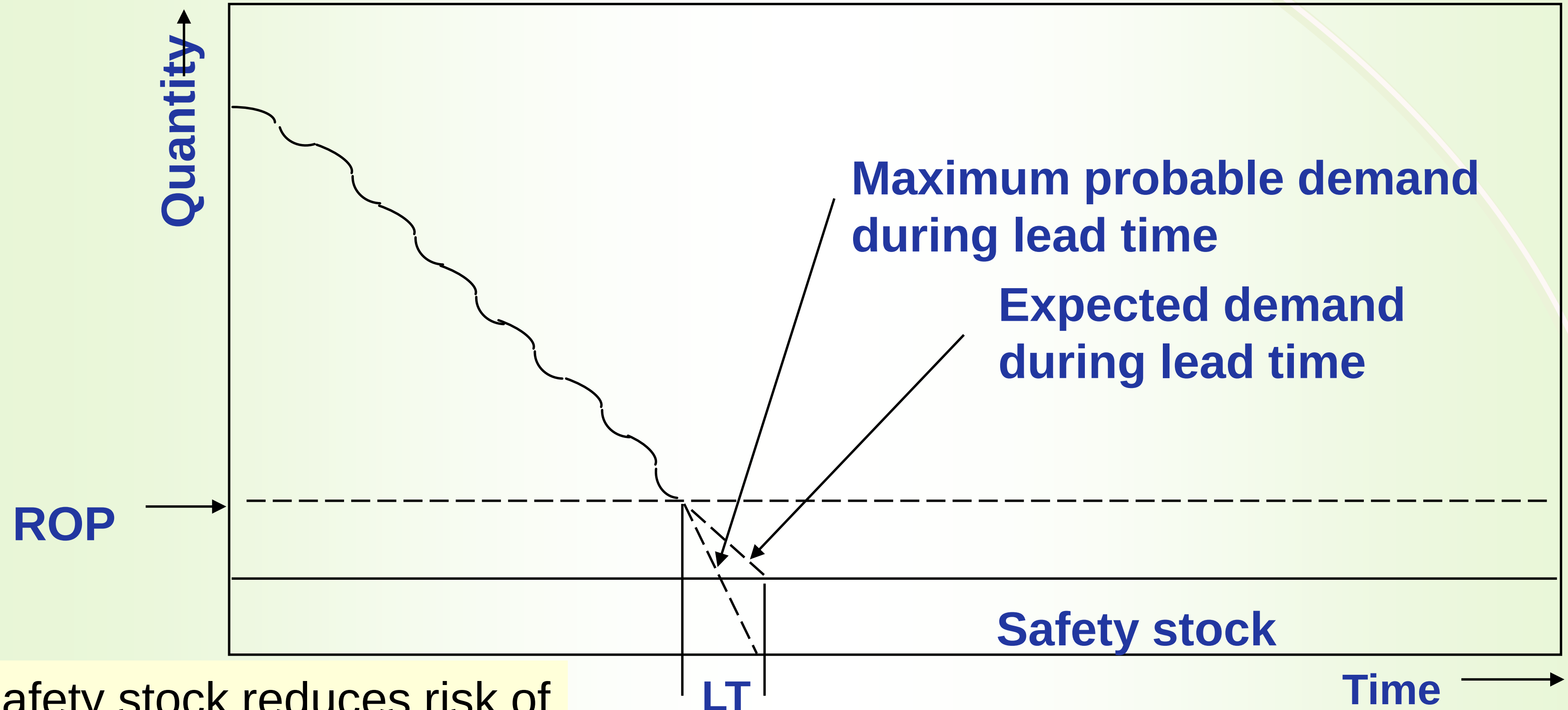
When to Reorder with EOQ Ordering

- ***Reorder Point*** - When the quantity on hand of an item drops to this amount, the item is reordered.
- ***Safety Stock*** - Stock that is held in excess of expected demand due to variable demand rate and/or lead time.
- ***Service Level*** - Probability that demand will not exceed supply during lead time.

Determinants of the Reorder Point

- The rate of demand
- The lead time
- Demand and/or lead time variability
- Stock-out risk (safety stock)

Safety Stock



Safety stock reduces risk of
Stock-out during lead time

REORDER TIME METHODS

Reorder Point Methods

- Intuitive methods
- Systemic want-book system
- Fixed interval system
- S and S method (Variable interval and variable quantity)
- Single order and scheduled part delivery

Reorder Point Methods

- Intuitive method

  -want-book is maintained wherein items are recorded.

  -when number of units in stock reaches to determined point order is placed.

Reorder Point Methods

- Systematic want-book system

  - Want book is maintained for each product and each major wholesaler.

  -A card is attached to each product which contains information regarding minimum quantities, maximum quantities, number at which the order is to be placed.

  - Applicable to small pharmacies.

Reorder Point Methods

- Fixed Interval System

  - Items are ordered at regular intervals

  - Quantity to be procured varies depending on the stock falling down from maximum stock level.

Maximum stock level = safety stock + consumption rate × (review period + lead-time)

Reorder Point Methods

- S and S method

  - Here maximum stock and reorder levels are predetermined.

  - If the quantity is found to be less than the reorder level, order is placed.

  - Not a good system.

Reorder Point Methods

- Single order and scheduled part delivery

  - Annual requirements are included in a single contract with instructions to deliver in specified times.

  - Ideal for items which are used in small quantities, but at regular rate of usage.

Statistical Inventory Control or Reorder Point

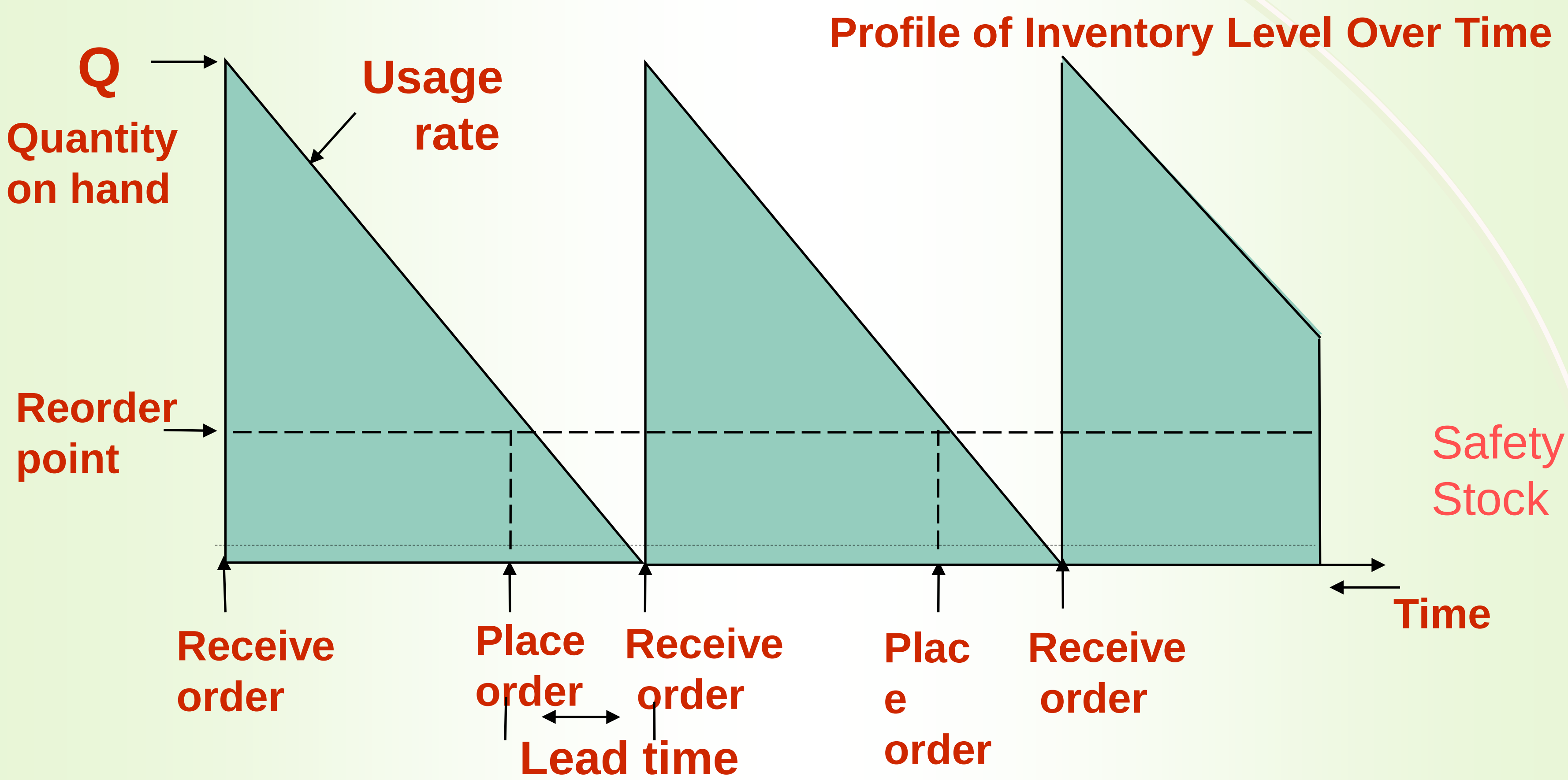
- Most companies use statistical inventory or reorder point system.
- Based on the past data, quantity and delivery date are separately predicted using statistics for each item.

Reorder Point

- Assumptions
  - Usage of the items is random.
  - Demand during lead-time is random.
  - Depletion of inventory is gradual.
  - Average inventory is equal to one-half of the order quantity.
  - Lead-time is pre-determined.

ROP = reserve stock + anticipated demand during lead-time

The Inventory Cycle



Disadvantages of Statistical Inventory Control

- Predicts the quantity and delivery date for each item separately.
- Applied where demand is independent.

EXAMPLE : 1,000 kg of a raw material is consumed in February and further this material is not needed until June. Since the order point system dictates immediate replenishment, a large inventory may result though it is not for immediate use.

Methods followed for production

FIFO: First In First Out

Under the FIFO method, the costs of items sold in the current period are considered to be the earliest costs in inventory prior to the sale.

RECENT TRENDS AGAINST INFLATION

LIFO: Last In First Out

CONCLUSION

- Study of deterministic models to understand the basics.
- Demand assumed to be stable and no possibility given to adapt the order size
- No consideration of unpredictable demand (stochastic models)
- Inventory Management often a political decision
- Cost estimation based on historical, average value.

REFERENCES

1) C.V.S. SUBRAMANYAM; "**PRODUCTION MANAGEMENT**" IN '**PHARMACEUTICAL PRODUCTION AND MANAGEMENT**', VALLABH PRAKASHAN, Pg No.292-312.

2) LEON LACHMAN, HERBERT LIEBERMAN, JOSEPH KANIG;"**INVENTORY MANAGEMENT**" IN '**THE THEORY AND PRACTISE OF INDUSTRIAL PHARMACY**', 3rd EDITION, VARGHESE PUBLICATION, Pg No. 747-759.

3) http://en.wikipedia.org/wiki/Inventory_management.

*EVERYTHING IS **DIFFICULT***
IF YOU CRY,
*EVERYTHING IS **EASY***
IF YOU TRY.