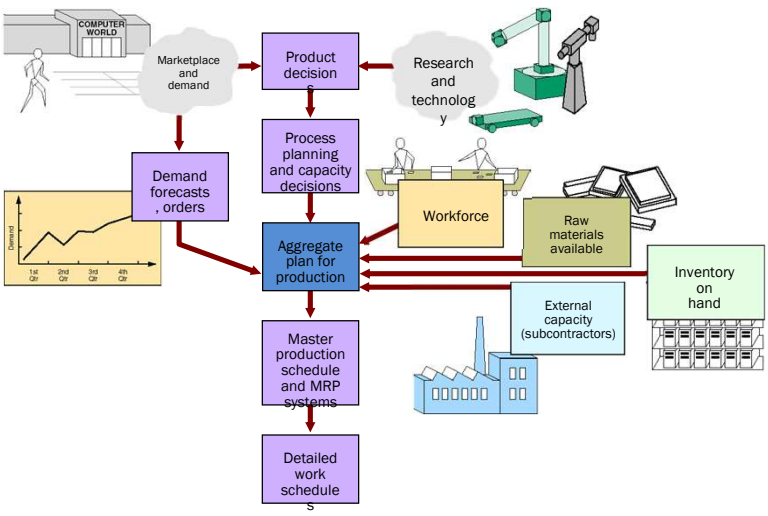
Supply Planning and Inventory Management



Inventory Management

- Involves planning, coordinating, and controlling
  - Acquisition, storage, handling, movement, distribution, and possible sale of raw materials
  - Component parts and subassemblies
  - Supplies and tools
  - Replacement parts
  - Other assets that are needed to meet customer wants and needs

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Types of Inventory

- Raw materials, component parts, subassemblies, and supplies
  - Inputs to manufacturing and service-delivery processes
- Work-in-process (WIP) inventory
  - Partially finished products in various stages of completion that are awaiting further processing
- Finished-goods inventory
  - Completed products ready for distribution or sale to customers
- Safety stock inventory
  - Additional amount of inventory kept over and above the average amount required to meet demand

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Why inventories?

- Economies of Scale
- Supply and Demand Uncertainty
- Volume Discounts/Impending Price Rise
- Long Lead Times and Quick Response to Customer's Demand
- To maintain independence of operations
- To allow flexibility in production scheduling

Inventory Characteristics, Part 1

- Each item is assigned a unique identifier, called a stock-keeping unit (SKU)
  - **Stock-keeping unit (SKU)**: Single item or asset stored at a particular location
- Nature of demand
  - **Independent demand**
    - Demand for an SKU that is unrelated to the demand for other SKUs and needs to be forecasted

Inventory Characteristics, Part 2

- Dependent demand
  - Directly related to the demand of other SKUs and can be calculated without needing to be forecasted
- Static demand is stable in nature
- Dynamic demand varies over time

- Storage planning approaches
  - Analyzing inventory for single or multiple periods

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Inventory Characteristics, Part 3

- Lead time
  - Time between placement of an order and its receipt
- Stockouts
  - Inability to satisfy the demand for an item
    - Backorder: Occurs when a customer is willing to wait for an item
    - Lost sale: Occurs when the customer is unwilling to wait and purchases the item elsewhere

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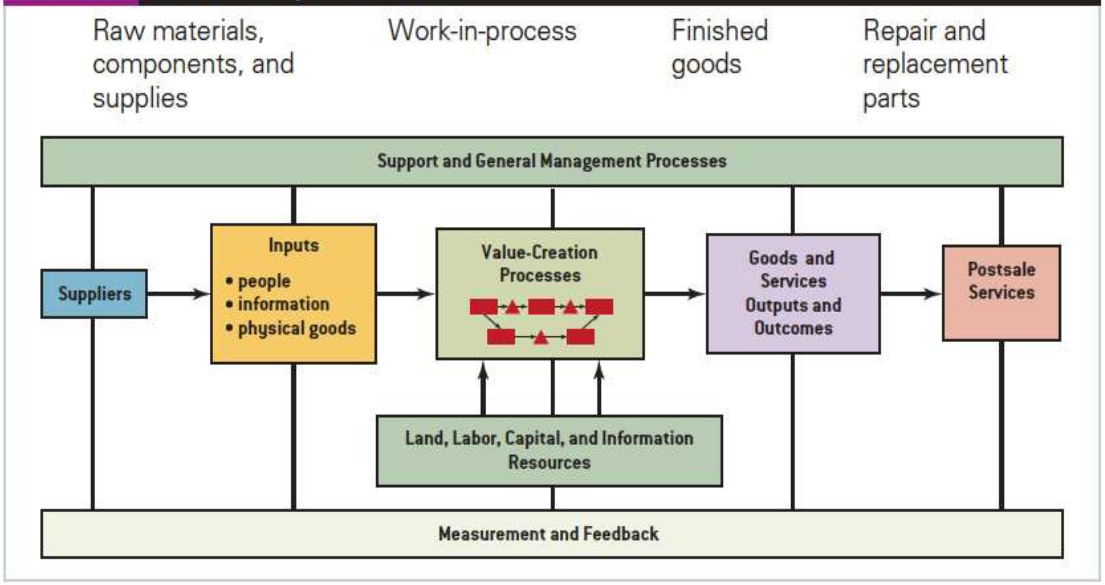
Role of Inventory in the Value Chain

EXHIBIT 12.1 Role of Inventory in the Value Chain



Inventory

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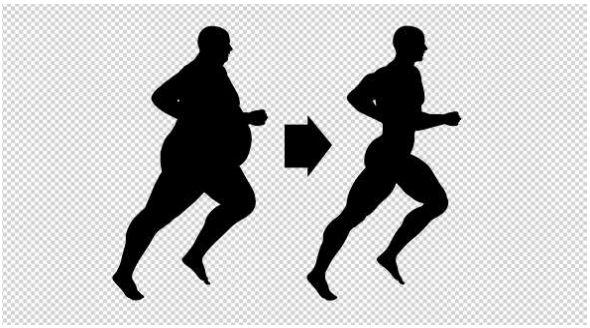
Inventory is injurious to your health!



Get Lean…Get healthy!

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Inventory Hides Problems

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We want to turn our inventory faster than our people

- A quote by James D. Sinegal
  - Co-founder, Costco

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Inventory Turns

"It was someone from corporate's idea to improve our inventory turns."

$$IT_{sit} = \frac{CGS_{sit}}{\frac{1}{4}\sum_{q=1}^{4} Inv_{sitq}},$$

$$\text{Inventory Turns} = \frac{\text{Cost of Goods Sold}}{\text{Average Inventory}}$$

Should be as high/low as possible

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Inventory classification

- Classification by form
  - Raw Materials (RM)
  - Work-in-Process (WIP)
  - Finished Goods (FG)
- Classification by Life cycle
  - Perishable
  - Non-perishable

Inventory classification by function

- Cyclic stock
  - Ordering lot size/2
- Safety stock
  - To protect against uncertainties
- Pipeline
  - Scheduled receipts or open orders

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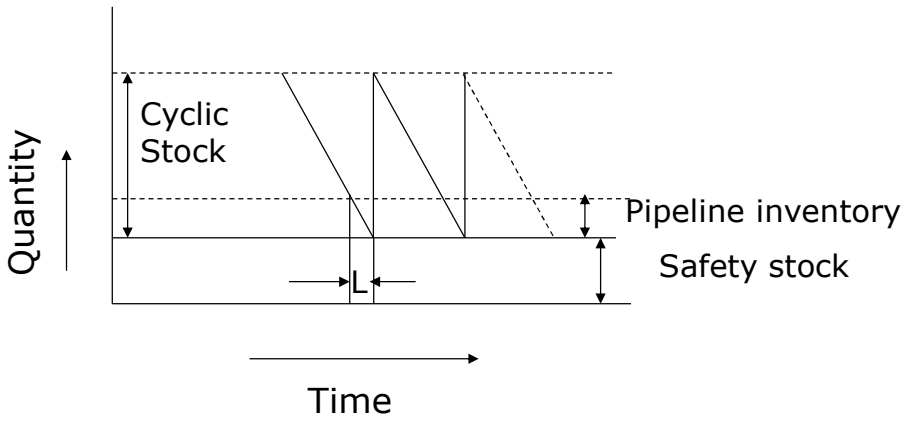
Cyclic, Pipeline and Safety Stocks



Cyclic inventory, pipeline inventory and safety stocks are critically linked to "how much" and "when" decisions in inventory planning

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"I guess smaller, more frequent deliveries are out of the question?"

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Costs of Inventory

- Physical holding cost (*out-of-pocket*)
- Financial holding cost (*opportunity cost*)

- Holding (or carrying) costs

- Production change
- Product changeover

- Setup costs

- Low responsiveness
  - to demand/market changes
  - to supply/quality changes

- Shortage costs

- Managerial and clerical costs
- Transportation costs

- Ordering Costs

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Inventory Policy parameters

- WHEN to order?
- HOW MUCH to order?

- In WHAT FORM? *(RM, WIP or FG)*
- WHERE TO DEPLOY in the supply chain?

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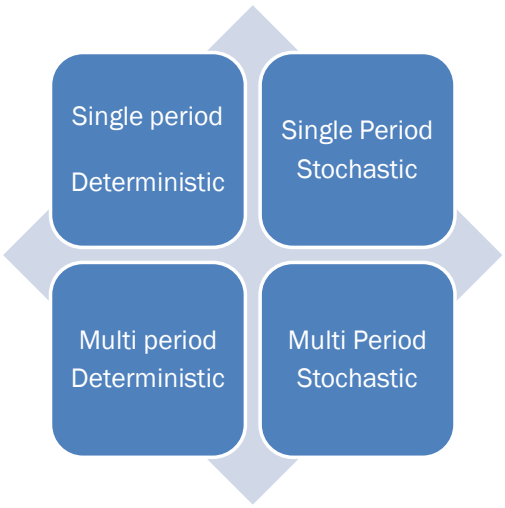
Types of inventory models



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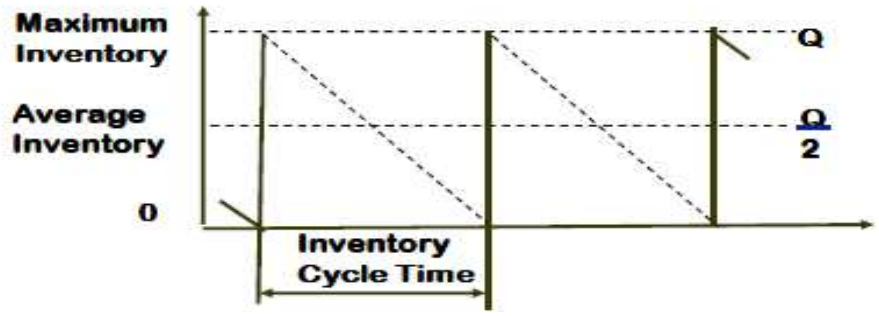
Multi Period Deterministic

- Perpetual inventory system
- Demand for the product is known constant and uniform throughout the period
- Lead time (time from ordering to receipt) is constant
- Replenishment is instantaneous
- Price per unit of product is constant
- Inventory holding cost is based on average inventory
- Ordering or setup costs are constant
- All demands for the product will be satisfied (no back orders are allowed)
- How would the inventory level look like?



- What should be the ordering quantity (Q)?

Tradeoffs: Inventory Carrying versus Annual Ordering Costs

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

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EOQ model

D: Demand per year
S: Setup or Order Cost (Rs/Setup; Rs/Order)
c= unit cost of item
h = Inv holding cost rate
H=hc: Inventory holding cost
(Rs./year/unit)
Q: Order quantity
T: Reorder cycle

$$Q^* = \sqrt{\frac{2DS}{H}}$$

$$T = \frac{Q^*}{D} = \sqrt{\frac{2S}{DH}}$$

$$TC(Q^*) = \sqrt{2SDH}$$

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Inventory Planning Models

Mean of weekly demand : 200

Unit cost of the raw material : Rs. 300/-
Ordering cost : Rs. 460/- per order
Carrying cost percentage : 20% per annum

EOQ Model
Weekly demand = 200
Number of weeks per year = 52
Annual demand, D = 200*52 = 10,400
Carrying cost, C_c = Rs. 60.00 per unit per year

Economic Order Quantity = $\sqrt{\frac{2DS}{H}} = \sqrt{\frac{2 * 460 * 10,400}{60}} = 399.33 \approx 400$

Time between orders = $\frac{400}{10400} = \frac{2}{52} = 2\ weeks$

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Practical issues with the EOQ model

- It may not be possible to
  - Order exactly Q*
    - Order as close as possible to Q*
  - Estimate the parameters (D,S,H) accurately
    - EOQ model is robust to small errors in these values
  - Instantaneous replenishment
    - Incorporate lead time using ROP level
  - Price discounts
    - Use modified procedure

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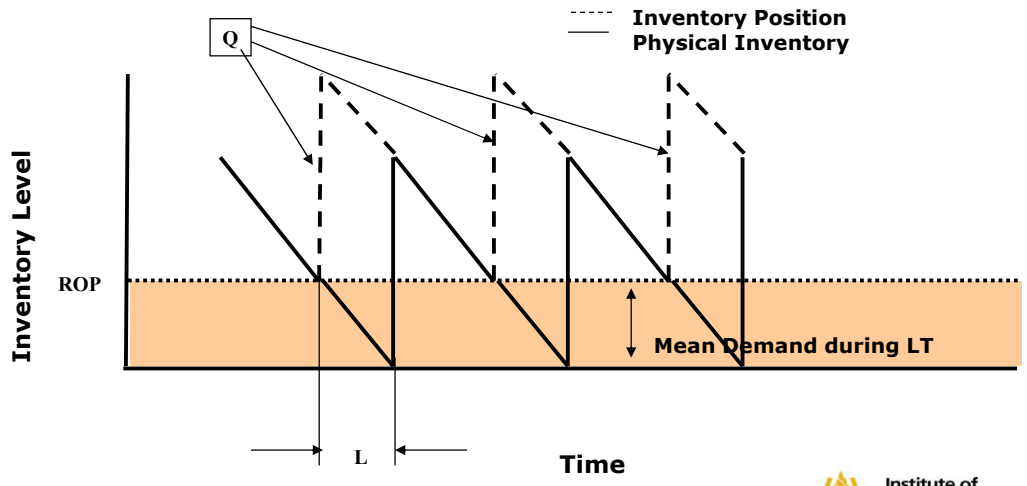
Certain Demand



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Price Discounts

- Why do suppliers give price discounts?
- Compute Q* values
  - From lowest price to the highest
  - Until valid Q* is obtained
- Compute TRC at this Q* and each price break above this Q*
- Choose the order quantity with least TC

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The elephant in the room

Demand uncertainty!!!

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Who's the biggest villain in Operations?

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If life were predictable it would cease to be life, and be without flavor.

Eleanor Roosevelt

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Single period Stochastic Demand

- Examples?
  - Newspapers
  - Cakes
  - Fashion products?

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Demand characteristics

- Demand follows a normal distribution
  - NORM(50,10)
- How much would you order?

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Managing the average will make you an average manager!

A quote by

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Understanding Service level

- What area of the demand distribution would you cover?

http://homepage.divms.uiowa.edu/~mbognar/applets/normal.html

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Optimal Service level

Happiness is a mysterious thing, to be found somewhere between too little and too much

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Newsvendor model

- Inventory decision under uncertainty
- The “too much/too little problem”:
  - Order too much and inventory is left over at the end of the season
  - Order too little and sales are lost.

Notation

- Demand D is a random variable
  - Cumulative distribution function F(D)
- Wholesale price W
- Selling price R
- Salvage value S (<W)
- How much should the retailer order?

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"Too much" and "too little" costs

- C_o = overage cost
  - The cost of ordering one more unit than what you would have ordered had you known demand.
  - Increase in profit you would have enjoyed had you ordered one unit lesser.
  - C_o = *Cost – Salvage value* = $W - S$ =
- C_u = underage cost
  - The cost of ordering one fewer unit than what you would have ordered had you known demand.
  - Increase in profit you would have enjoyed had you ordered one unit more.
  - C_u = *Price – Cost* = $R - W$ =

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Expected profit maximizing order quantity

- To minimize the expected total cost of underage and overage, order Q units so that the expected marginal cost with the Q^{th} unit equals the expected marginal benefit with the Q^{th} unit:

$$C_o \times F(Q) = C_u \times (1 - F(Q))$$

- Rearrange terms in the above equation ->

$$F(Q) = \frac{C_u}{C_o + C_u}$$

- The ratio $C_u / (C_o + C_u)$ is called the *critical ratio*.
  - In other terms, *(R-W)/(R-S). R and S are determined by the market.*

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What is the Optimal service level?

Let C_o = Cost of over stocking per unit
C_u = Cost of under stocking per unit
Q = Number of units to be stocked
d = Single period demand
$P(d \le Q)$ = The probability of the single period demand being at most Q units

$$P(d \le Q) \le \frac{C_u}{C_u + C_o} = \text{Service Level}$$

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TOO MUCH INVENTORY
TOO LITTLE INVENTORY

$$P(d \le Q) \le \frac{C_u}{C_u + C_o}$$

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Selective Control of Inventories

- ABC Classification (on the basis of consumption value)
- XYZ Classification (on the basis of unit cost of the item)
  - High Unit cost (X Class item)
  - Medium Unit cost (Y Class item)
  - Low unit cost (Z Class item)
- FSN Classification (on the basis of movement of inventory)
  - Fast Moving
  - Slow Moving
  - Non-moving
- VED Classification (on the basis of criticality of items)
  - Vital
  - Essential
  - Desirable
- On the basis of sources of supply
  - Imported
  - Indigenous (National Suppliers)
  - Indigenous (Local Suppliers)

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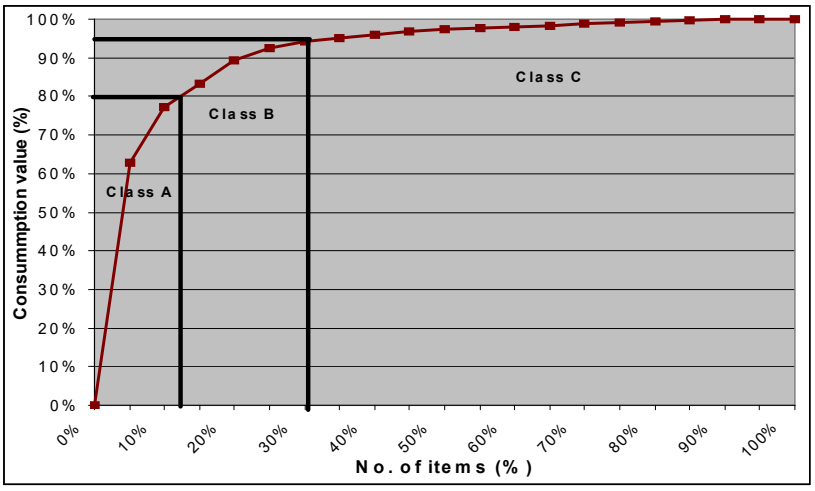
ABC Classification



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ABC Inventory Analysis

- Categorizes SKUs into groups according to their total annual dollar usage
  - Total dollar usage = Item usage (volume) x Item's dollar value (unit cost)
  - A items - Account for a large dollar value but a relatively small percentage of total items
  - C items - Account for a small dollar value but a large percentage of total items
  - B items - Items between A and C

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Inventory Management in Practice

- Problem of Shrinkage
  - Stock mismatch
- Inventory Management software
- RFID technology
- IoT tech

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"You've got oink oinks here, cluck clucks there, and the moo moos are everywhere! You have got to get a handle on this inventory!"

THANK YOU

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