

# Inventory Management

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Lecture 8



# Inventory

# Inventory

- **Inventory**
  - A stock or store of goods
- **Independent-demand items**
  - Items that are ready to be sold or used



**The average inventory level is positively related to order size.**

Inventories are a vital part of business:

- (1) necessary for operations
- (2) contribute to customer satisfaction

**A “typical” firm has roughly 30% of its current assets and as much as 90% of its working capital invested in inventory**

## What are the 5 elements of inventory management?

An efficient inventory management process should cover:

1. Planning & forecasting
2. purchasing & ordering
3. receiving & storing
4. packing, inventory tracking,
5. order fulfillment.



**Inventory is at the core of any successful business, ensuring an appropriate balance between supply and demand.**

# Types of Inventory

1. Raw materials and purchased parts
2. Work-in-process (WIP)
3. Finished goods inventories or merchandise
4. Tools and supplies
5. Maintenance and repairs (MRO) inventory
6. Goods-in-transit to warehouses or customers (pipeline inventory)

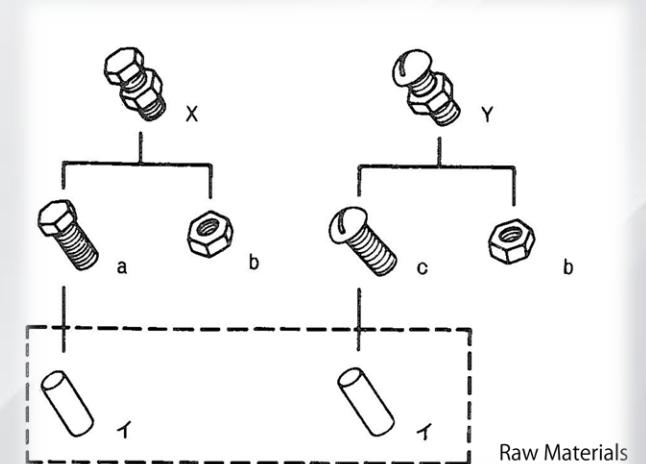


# Types of Inventory: # 1

## Raw materials and purchased parts

the total cost of a manufacturer's components, subassemblies, and supplies in stock that are not currently in production. There are two types of raw materials that go into making a final product: Direct materials (DM)

Indirect materials (IM)



# Types of Inventory: # 2

## Work-in-process (WIP)

Work in process (WIP) inventory refers to materials that are waiting to be assembled and sold. WIP inventory includes the cost of raw materials, labor, and overhead costs needed to manufacture a finished product



# Types of Inventory: # 3

## Finished goods inventories or merchandise

Finished goods are products that go through the production process and are completed and ready for sale. Retailers typically refer to this inventory as merchandise. Common examples of merchandise include electronics, clothes, and cars held by retailers.



# Types of Inventory: # 4

## Tools and supplies

Inventory is items subject to sale, rent or leases. Supplies are things consumed in your normal course of business



# Types of Inventory: # 5

## Maintenance and repairs (MRO) inventory

MRO inventory comprises the consumable materials, equipment and supplies needed for maintenance, repair and operations activities.

MRO includes items that are used in a production process but — unlike raw materials — are not incorporated into a company's finished products

### What is MRO?



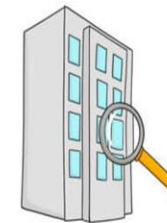
Production equipment  
repair and maintenance



Material handling equipment  
repair and maintenance



Managing tools and  
consumables



Infrastructure maintenance



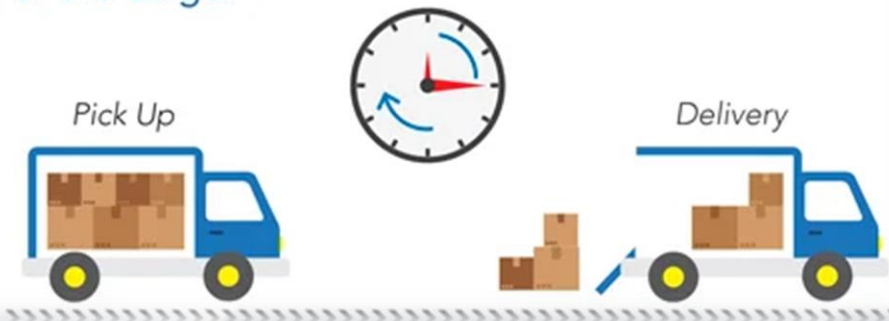
Supply chain management  
and procurement

# Types of Inventory: # 6

## Goods-in-transit to warehouses or customers (pipeline inventory)

In-transit inventory is products that have been shipped by the seller but have yet to reach the customer. These goods are also called goods-in-transit, pipeline inventory, or transportation inventory.

The total time of transit from pick up to delivery of the cargo.



# Inventory Functions

- Inventories serve several functions such as:
  1. To meet anticipated customer demand
  2. To smooth production requirements
  3. To decouple operations
  4. To protect against stockouts
  5. To take advantage of order cycles
  6. To hedge against price increases
  7. To permit operations
  8. To take advantage of quantity discounts



**Decoupling refers to buffering operations in manufacturing.**

# Objectives of Inventory Control

- Inventory management has two main concerns:

## 1. Level of customer service

- Having the right goods available in the right quantity in the right place at the right time



# Objectives of Inventory Control

## 2. Costs of ordering and carrying inventories

The overall objective of inventory management is to achieve satisfactory levels of customer service while keeping inventory costs within reasonable bounds

1. Measures of performance

2. Customer satisfaction

- Number and quantity of backorders
- Customer complaints

3. Inventory turnover

**There is a limit to how high service level can go; if the competitor's service level is 90 percent, the retailer can't double that.**



# Inventory Turnover Ratio

- Ratio of annual cost of goods sold to average inventory investment
  - How many times a year the inventory is sold
  - Higher the better as it implies more efficient use of the inventory

**Larger order quantities lead to higher inventory carrying cost.**

$$\text{Inventory Turnover Ratio} = \frac{\text{Cost of Goods Sold (COGS)}}{\text{Average Inventory}}$$

# Effective Inventory Management

- Requires:
  1. A system keep track of inventory
  2. A reliable forecast of demand
  3. Knowledge of lead time and lead time variability
  4. Reasonable estimates of
    - Holding costs
    - Ordering costs
    - Shortage costs
  5. A classification system for inventory items

**Many buffers increase costs across supply chains.**

# Inventory Counting Systems

- **Periodic system**
  - Physical count of items in inventory made at periodic intervals
- **Perpetual inventory system**
  - System that keeps track of removals from inventory continuously, thus monitoring current levels of each item
  - An order is placed when inventory drops to a predetermined minimum level
- **Two-bin system**
  - Two containers of inventory; reorder when the first is empty (ROP)
  - second bin equals the amount needed during lead time in addition to any safety stock

# **Inventory Counting Technologies**

- **Universal product code (UPC)**
  - Bar code printed on a label that has information about the item to which it is attached
- **Radio frequency identification (RFID) tags**
  - A technology that uses radio waves to identify objects, such as goods, in supply chains

# Inventory Costs

- **Purchase cost**
  - The amount paid to buy the inventory
  - It is typically the largest of all inventory costs.
- **Holding (carrying) costs**
  - Cost to carry an item in inventory for a length of time, usually a year
  - costs are expressed in monetary terms, whether as a set value or as a percentage of the per-unit cost.

# Inventory Costs cont.

- **Ordering costs**

- Costs of ordering and receiving inventory

- **Setup costs**

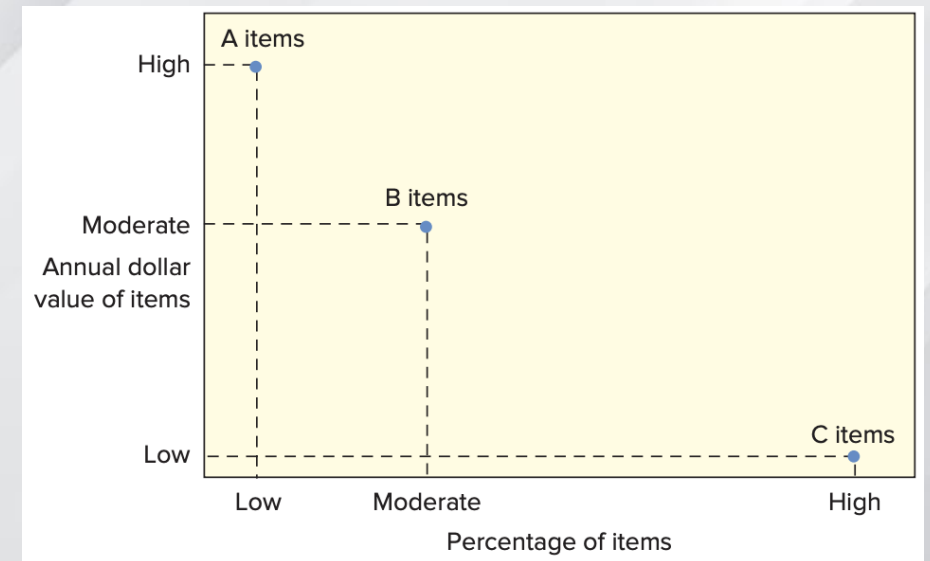
- The costs involved in preparing equipment for a job
- Analogous to ordering costs

- **Shortage costs**

- Costs resulting when demand exceeds the supply of inventory; often unrealized profit per unit
- These costs can include the opportunity cost of not making a sale, loss of customer goodwill, late charges, backorder costs, and similar costs.

# ABC Classification System

- Classifying inventory according to some measure of importance, and allocating control efforts accordingly
- **A items** (very important)
  - 10 to 20 percent of the number of items in inventory and about 60 to 70 percent of the annual dollar value
- **B items** (moderately important)
- **C items** (least important)
  - 50 to 60 percent of the number of items in inventory but only about 10 to 15 percent of the annual dollar value



# Cycle Counting

- **Cycle counting**

- A physical count of items in inventory
- Cycle counting management
  - How much accuracy is needed?
    - A items:  $\pm 0.2$  percent
    - B items:  $\pm 1$  percent
    - C items:  $\pm 5$  percent
  - When should cycle counting be performed?
  - Who should do it?



# How Much to Order: EOQ Models

- Economic order quantity models identify the optimal order quantity by minimizing the sum of annual costs that vary with order size and frequency
  1. The basic economic order quantity model
  2. The economic production quantity model
  3. The quantity discount model

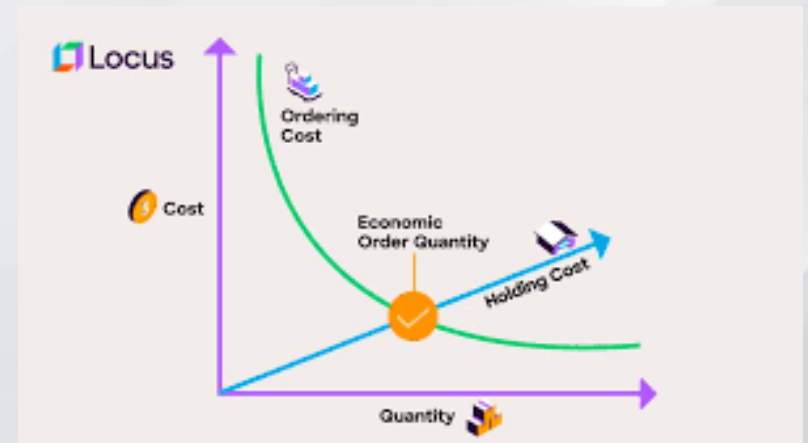


# Economic order quantity models

## EOQ Models

### 1. The basic economic order quantity model (EOQ)

The overall goal of economic order quantity is to decrease spending; its formula is used to identify the greatest number of units needed (per order) to reduce buying.



# Basic EOQ Model

- The basic EOQ model is used to find a fixed order quantity that will minimize total annual inventory costs
- Assumptions:
  1. Only one product is involved
  2. Annual demand requirements are known
  3. Demand is even throughout the year
  4. Lead time does not vary
  5. Each order is received in a single delivery
  6. There are no quantity discounts

# Total Annual Cost

Total Cost = Annual Holding Cost + Annual Ordering Cost

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

where

$Q$  = Order quantity in units

$H$  = Holding (carrying) cost per unit, usually per year

$D$  = Demand, usually in units per year

$S$  = Ordering cost per order

# Deriving EOQ

- Using calculus, we take the derivative of the total cost function and set the derivative (slope) equal to zero and solve for Q.
- The total cost curve reaches its minimum where the carrying and ordering costs are equal.

$$Q_o = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(\text{annual demand})(\text{order cost})}{\text{annual holding cost per unit}}}$$

- Length of the optimal order cycle =  $Q_o / D$

# Economic order quantity models EOQ Models

## 2. The economic production quantity model ( EPQ)

(EPQ) model is used to determine the optimal order quantity that an organization should place with a supplier to minimize inventory costs, while balancing inventory holding and average fixed order costs



# Economic Production Quantity (EPQ)

- The batch mode is widely used in production. In certain instances, the capacity to produce a part exceeds its usage (demand rate).
  - Assumptions
    - Only one item is involved
    - Annual demand requirements are known
    - Usage rate is constant
    - Usage occurs continually, but production occurs periodically
    - The production rate is constant
    - Lead time is known and constant
    - There are no quantity discounts

# EPQ – Total Cost

$$\begin{aligned} TC_{\min} &= \text{Carrying Cost} + \text{Setup Cost} \\ &= \left( \frac{I_{\max}}{2} \right) H + \frac{D}{Q} S \end{aligned}$$

where

$I_{\max}$  = Maximum inventory

$$= \frac{Q_p}{p} (p - u)$$

$p$  = Production or delivery rate

$u$  = Usage rate

# Economic order quantity models

## EOQ Models

### 3. The quantity discount model

a pricing strategy in which companies offer lower prices to customers that purchase large quantities of a product. Quantity discounts are meant to entice customers to buy more products, often leading to increased overall revenue and production cost savings for companies.



Bulk  
Purchasing



Quantity  
Discount



Reduced  
Price

# Quantity Discount Model

- **Quantity discount**

- Price reduction for larger orders offered to customers to induce them to buy in large quantities

Total Cost = Carrying Cost + Ordering Cost + Purchasing Cost

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

where

$P$  = Unit price

# When to Reorder

- **Reorder point ( ROP)**

- When the quantity on hand of an item drops to this amount, the item is reordered.
- Determinants of the reorder point
  1. The rate of demand
  2. The lead time
  3. The extent of demand and/or lead time variability
  4. The degree of stockout risk acceptable to management

# Safety Stock?

- As the amount of safety stock carried increases, the risk of stockout decreases.
  - This improves customer service level
- **Service level**
  - The probability that demand will not exceed supply during lead time
  - Service level =  $100\% - \text{stockout risk}$

# How Much Safety Stock?

- The amount of safety stock that is appropriate for a given situation depends upon:
  1. The average demand rate and average lead time
  2. Demand and lead time variability
  3. The desired service level

$$\text{ROP} = \text{Expected demand during lead time} + z\sigma_{dLT}$$

where

$z$  = Number of standard deviations

$\sigma_{dLT}$  = The standard deviation of lead time demand

# Single-Period Model

- The goal of the single-period model is to identify the order quantity that will minimize the long-run excess and shortage costs
- Two categories of problem:
  - Demand can be characterized by a continuous distribution
  - Demand can be characterized by a discrete distribution

# Single-Period Model (cont.)

- **Single-period model**

- Model for ordering of perishables and other items with limited useful lives

- **Shortage cost**

- Generally, the unrealized profit per unit
- $C_{shortage} = C_s = \text{Revenue per unit} - \text{Cost per unit}$

- **Excess cost**

- Different between purchase cost and recover value of items left over at the end of the period
- $C_{excess} = C_e = \text{Cost per unit} - \text{Recover value per unit}$

# Benefits of Inventory Management



# Disadvantages of Inventory

- Higher costs
  - Item cost (if purchased)
  - Ordering (or setup) cost
    - Costs of forms, clerks' wages etc.
  - Holding (or carrying) cost
    - Building lease, insurance, taxes etc.
- Difficult to control
- Hides production problems



Thank You