

INVENTORY MANAGEMENT

Learning Objectives:

1. Purposes of inventory
2. Inventory control systems
3. Inventory costs
4. EOQ models Formula Sheet right amount to order to minimize costs
5. Safety stock Formula Sheet "buffer" at the bottom just in case

1. Introduction

- **Inventory:** A stock of items or materials held to satisfy eventual demand - to meet demand (service customers)
- Raw materials, purchased parts and supplies
- Work-in-process (partially completed) products (WIP)
- Finished goods
- Rework items - flaws - returns
- Tools, machinery, and equipment
- Labour - accounting, law, clinic
↳ inventory! Can't work w/o people

- Types of inventory based on different purposes

- Anticipation inventory – to meet demand forecast (e.g., seasonality)
- Safety stock – buffer to protect against uncertainties (just in case)
- Lot-size inventory – result of batch ordering (you don't need it)
- Pipeline inventory – in transit ("lead-time")
↳ in the system (not on your dock)
- Hedge inventory – to protect against future events (e.g., price increase of raw materials) (gamble/bet investing to make/save money)
- Maintenance, Repair and Operating (MRO) inventory – to minimize disruptions to general operations and maintenance "nuts & bolts"
- Decoupling – work-in-process items waiting for the next step (still WIP)
↳ taken off the assembly line

→ Home Dept ordering generators for Hurricane

WIP → most costly (can't sell off easily)

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- Why keep inventory?

- Buffer against expected & unexpected changes
- Faster customer service
- Economies of scale (production, purchasing) EOQ
- Not to be dependent on suppliers

- Why is too much inventory bad?

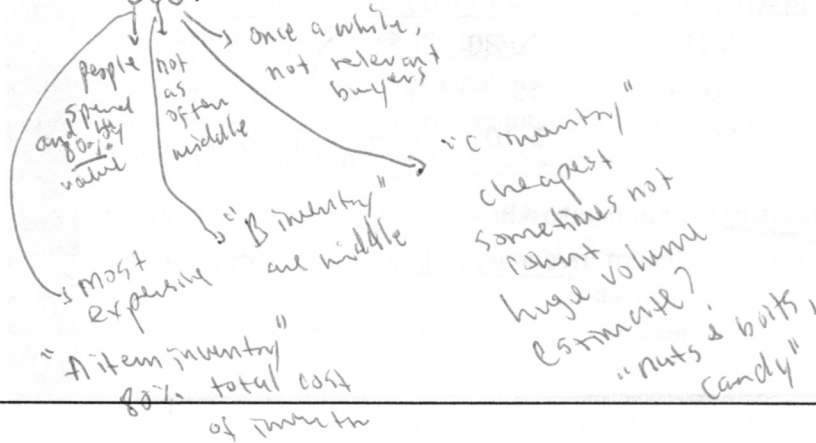
- Cost (ties up working capital, may deteriorate or get stolen)
 - Need for storage space
 - Need for labour (material handling, transfer) opportunity cost
 - Complacency 3% Prem.
 - Insurance (cost of inv. → "dead inventory" ups insurance premium)
- General objective: To keep enough inventory to meet customer demand and be cost efficient

→ Main operational concerns: When to order and how many to order

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2. Inventory Control Systems

- Different ways of determining when & how many to order
 - Q system – fixed quantity *same qty every time (200 qty)*
 - P system – fixed time period *at a fixed time (Monday's)*
 - ABC system



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2.1 Q System vs. P System

Q System <i>qty fixed / time varies</i>	P System <i>time fixed / qty varies</i>
<ul style="list-style-type: none"> • Reorder a fixed quantity (Q) whenever the inventory falls to or below a reorder point (R) • <u>Continuous review system</u>: reviews the inventory each time a withdrawal occurs • <u>Time</u> between orders varies <i>- high priced items</i> 	<ul style="list-style-type: none"> • Reorder after a fixed time period (P) • <u>Periodic review system</u>: reviews the inventory periodically • <u>Order quantity (Q) varies</u> $Q = (\text{Target inventory level}) - (\text{Current inventory level})$ <i>Order for difference</i>

Compare in terms of record keeping system, administration cost, responsiveness to demand variability, average inventory level, and ease to combine orders to the same supplier

Q more expensive (administratively)

- cost inventory continuously

Q more responsive

- monitor every sale, response to demand immediately

Q simple to calc. average

- Q qty, P -> weighted average

P easier -> to combine orders

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2.2 ABC System

- An inventory classification system in which a small percentage of items (A-level) account for most of the inventory value

no. b.
Example of ABC

Level	% of units	% of dollar value (e.g., annual volume x unit cost)
A	5-15	70-80
B	30	15
C	50-60	5-10

← Q policy constant surveillance
← maybe Q or P
← P once a month

Step 1: Classify products into ABC categories

Step 2: Apply a different inventory policy to each category

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Inventory Management Policy (Example)

gas station

A items \$14

- High priority
- Tight control with regular review
- Carefully determined Q, frequent deliveries, continuous review
- Very accurate and detailed inventory records, update monthly

- cigarettes

B items \$4-8

- Moderate priority
- Moderate control with regular attention
- Order quantities or order points reviewed quarterly
- Batch updating of inventory records

- potato chips
- drinks

C items \$0.50

- Low priority
- Simple control
- Large inventories, visual review
- Simplified counting, annual review

- bubble gum
- nuts & bolts

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- petrol

- tires
- bags

- wiper blades

3. Inventory Management Costs

- **Ordering (set-up) cost:** Fixed cost incurred whenever a replenishment order is placed, regardless of the quantity
 - Requisition and purchase ordering, transportation and shipping, receiving and storage, inspection, accounting and auditing costs
- **Holding (carrying) cost:** Cost to keep one item in inventory for a period of time (usually one year)
 - \$ per unit per period or % of a unit cost/price * exam
 - Rent, heating, cooling, lighting, security, record keeping costs
 - Interest on loans, depreciation, obsolescence, spoilage
- **Shortage (stockout) cost:** Cost of not being able to meet customer demand
 - Loss of sales, loss of future sales, loss of production, penalties
missing brand of store
cigs at a store → *100000 customers*
 - Backorder: the order is filled from the next shipment

this could add up!!!

- Square footage, utilities of the "orderer desk"

i.e. $\frac{\$2/\text{unit} \times \text{holding cost } 25\%}{= \$0.50}$

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current examples

• Polar's automaker unable to meet customer demands

4. Economic Order Quantity (EOQ) Models

- For managing anticipation inventory
- Mathematical model for determining order quantity and when to reorder

Assumptions:

- Demand is independent, known, and constant
- Supply is certain and received all at once in a batch
- Replenishment lead time is known and constant
 - Lead time: Time between order placed and order received
- Cost information is fixed and constant
- No shortages and no back orders

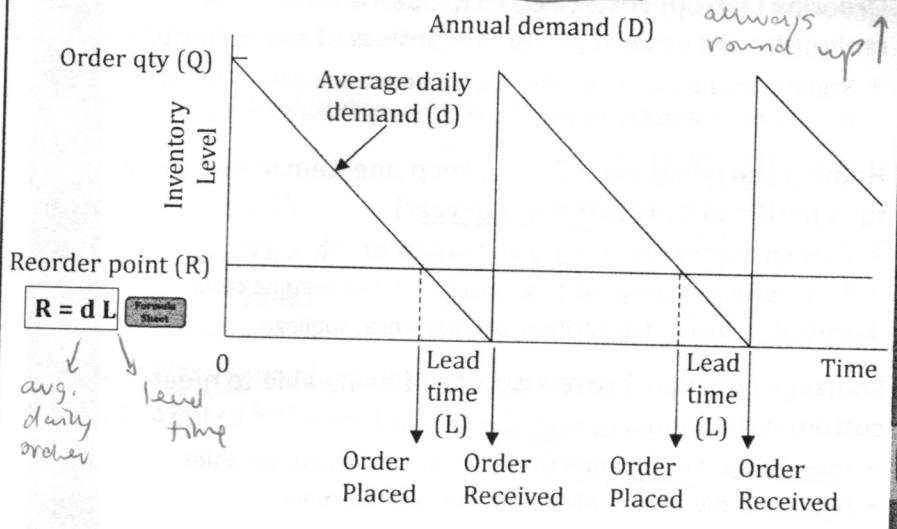
not really reflecting real world

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but the model will work

working days: 310 days

EOQ Inventory Model: **Order cycle time** Formula Sheet
 $= (\text{No. of days in a year}) / (\text{No. of orders})$



R = d L Formula Sheet

m q+y

avg. daily order

lead time

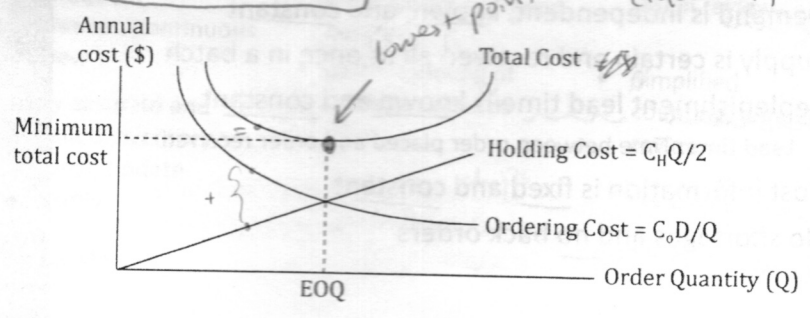
4.1 Basic Model

- Total annual inventory management cost (TC)
 $= (\text{Annual ordering cost}) + (\text{Annual holding cost})$
 $= (\text{Ordering cost}) \times (\text{No. of orders}) + (\text{Holding cost}) \times (\text{Average inventory})$

$\Rightarrow TC = C_o (D/Q) + C_H (Q/2)$ Formula Sheet

- EOQ objective: to minimize TC

$\Rightarrow EOQ = (2DC_o / C_H)^{1/2}$ Formula Sheet



Example 1: Western Jeans Company (WJC) purchases denim from Huron Textile Mills. WJC uses 36,000 yards of denim per year. The cost of ordering denim from Huron is \$500 per order. It costs Western \$0.40 per yard annually to hold a yard of denim in inventory.

a) What is the total inventory cost if each order is for 6000 yards?

$$TC = 500 \left(\frac{36,000}{6,000} \right) + 4 \left(\frac{6,000}{2} \right)$$

$$TC = \$4,200 \text{ (6,000 yards)}$$

b) What is the total inventory cost if denim is ordered every month?

$$TC = 500 \left(\frac{36,000}{3,000} \right) + 4 \left(\frac{3,000}{2} \right)$$

$$= \$6,600 \text{ (3,000 yards)}$$

c) Calculate the optimal order quantity and the total annual inventory cost.

$$Q^* = \sqrt{2 \left(\frac{DC_0}{C_H} \right)}$$

$$= \sqrt{2 \left(\frac{36,000(500)}{0.4} \right)}$$

$$= 9,486.83$$

$$= 9,487 \text{ units (EOQ)}$$

$$TC = 500 \left(\frac{36,000}{9,487} \right) + 4 \left(\frac{9,487}{2} \right)$$

$$= 3,794.74$$

$$D = 36,000$$

$$C_0 = \$500$$

$$C_H = \$0.40$$

$$6,000 = \$4,200$$

$$3,000 = \$6,600$$

$$EOQ 9,487 = \$3,794.74$$

absolutely lowest point we should order

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4.2 Quantity Discount Model

- **Quantity discount:** A price discount on an item if a predetermined number of units is ordered

- Total annual inventory management cost (TC)

$$= (\text{Ordering cost}) + (\text{Holding cost}) + (\text{Purchase cost})$$

$$\Rightarrow TC = C_0 (D/Q) + C_H (Q/2) + P \cdot D$$

P = per unit purchase price

D = annual demand

(14)