Chapter 9

Inventory Management
Lecture Outline

- Basics of Inventory Management
- Inventory Systems
- Fixed-Order Quantity System
- Fixed-Time Period Systems
- Independent vs. Dependent Demand
- Managing Supply Chain Inventory
What is Inventory?

Inventory is quantities of goods in stock

- **Manufacturing Inventory**
  - raw materials
  - component parts
  - work-in-process (WIP)
  - finished goods

- **Service Inventory**
  - involves all activities carried out in advance of the customer’s arrival
Inventory Policy

Inventory policy addresses two questions concerning replenishment of inventory:

- When to order?
- How much to Order?
Reasons for Carrying Inventory

- Protect Against Lead Time Demand
- Maintain Independence of Operations
- Balance Supply and Demand
- Buffer Uncertainty
- Economic Purchase Orders
Types of Inventory

• Cycle Stock
  – inventory for immediate use
  – typically produced in batches (production cycle)

• Safety Stock
  – extra inventory carried for uncertainties in supply and demand
  – also called buffer stock

• Anticipation Inventory
  – inventory carried in anticipation of events
  – smooth out the flow of products in supply chain
  – also called seasonal or hedge inventory
Types of Inventory Continued

• Pipeline Inventory
  – inventory in transit
  – exists because points of supply and demand are not the same
  – also called transportation inventory

• Maintenance, Repair and Operating Items (MRO)
  – inventories not directly related to product creation
Inventory Costs

• Holding Cost
  – costs that vary with the amount of inventory held
  – typically described as a % of inventory value
  – also called carrying cost

• Ordering Cost
  – costs involved in placing an order
  – sometimes called setup cost
  – inversely related to holding cost

• Shortage Cost
  – occur when we run out of stock
Inventory Systems

Inventory systems answer the questions: 
*when to order* and *how much to order*

There are two categories:

• **Fixed-Order Quantity System**
  – an order of fixed quantity, Q, is placed when inventory drops to a reorder point, ROP

• **Fixed-Time Period System**
  – inventory is checked in fixed time periods, T, and the quantity ordered varies
Fixed-Order Quantity System

– assumes a constant demand rate of d

– the inventory position, IP, is reduced by a rate of d

– order placed when the reorder point, ROP is reached

– when inventory is received, the IP is increased by the order quantity, Q
Fixed-Order Quantity System Continued

– there is a lead time, L, during which we have to wait for the order

– inventory is checked on a continual basis

– Q is computed as the economic order quantity, EOQ
Fixed-Order Quantity System

**FIGURE 9.2** Fixed-order quantity system.
Fixed-Time Period System

- inventory levels checked in fixed time periods, T
- a target inventory level, R, is restored when order received
- sometimes called Periodic Review System
- quantity ordered varies:
  \[ Q = R - IP \]

where:  
- \( Q \) = order quantity
- \( R \) = target inventory level
- \( IP \) = inventory position
Fixed-Time Period System

**FIGURE 9.3** Fixed-time period system.
**FIGURE 9.4** Comparison of inventory systems.

<table>
<thead>
<tr>
<th></th>
<th><strong>Fixed-order quantity</strong></th>
<th><strong>Fixed-time period</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How much to order?</strong></td>
<td>Order quantity $Q = EOQ$</td>
<td>Order quantity $Q = R - IP$</td>
</tr>
<tr>
<td><strong>When to order?</strong></td>
<td>When inventory level drops to reorder point -- ROP</td>
<td>When review period arrives -- $T$</td>
</tr>
<tr>
<td><strong>Order quantity</strong></td>
<td>Fixed</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Recordkeeping</strong></td>
<td>Continual</td>
<td>Periodic—at review interval</td>
</tr>
<tr>
<td><strong>Size of inventory</strong></td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td><strong>Time to maintain</strong></td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td><strong>Type of items</strong></td>
<td>Higher valued items</td>
<td>Quantity discount options</td>
</tr>
</tbody>
</table>
Fixed-Order Quantity System

There are two main variables to calculate in the Fixed-Order Quantity System:

• Order Quantity (Q)
  – EOQ is the most Economic Order Quantity

• Reorder Point (ROP)

Assume:
  – demand (d), lead time (L), holding cost (H), stock-out cost (S), and unit price (C) are constant
Economic Order Quantity (EOQ)

The EOQ minimizes the total annual inventory cost

Total Cost = Purchase + Ordering + Holding cost

\[ TC = DC + \frac{D}{Q}S + \frac{Q}{2}H \]

where:

- TC = Total cost
- D = Annual demand
- C = Unit cost
- Q = Order quantity
- S = Ordering cost
- H = Holding cost
EOQ Continued

\[ TC = DC + \frac{D}{Q}S + \frac{Q}{2}H \]

• Notice: \( DC \) = Annual purchase cost

\[ \frac{D}{Q} = \# \text{ orders placed per year} \]

→ Annual ordering cost = \# orders/yr \times \text{cost/order}

\[ \frac{Q}{2} = \text{average inventory level} \]

→ Annual holding cost = avg. inventory \times \text{cost/unit}
EOQ Continued

**FIGURE 9.5** Total cost curve.
Solving for EOQ

The EOQ can be found by taking the derivative of TC with respect to Q and set = 0

• Total Cost Equation: \( TC = DC + \frac{(D/Q)S}{2} + \frac{(Q/2)H}{2} \)

• 1\text{st} Derivative: \( \frac{TC}{dQ} = 0 + \frac{-DS}{Q^2} + \frac{H}{2} = 0 \)

• Solve for Q optimal: \( EOQ = \sqrt{\frac{2DS}{H}} \)
EOQ Example

Given: Demand = 1000 items per month
Holding Cost = 15% of product cost
Ordering Cost = $300 per order
Product Cost = $60 per unit

• EOQ

\[
EOQ = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(12,000)(300)}{(0.15)(60)}} = 894.5 = 895
\]

• Orders per year

\[
\frac{D}{Q} = \frac{12,000}{895} = 13.4
\]

• Annual Holding Cost

\[
\left(\frac{Q}{2}\right)H = \left(\frac{895}{2}\right)9 = $4028
\]
Reorder Point (ROP)

The ROP provides enough inventory to ensure that demand is covered during the lead time (L)

ROP = Demand during Lead Time = dL

Given: Lead time = 1 week
d = 250 items/week

ROP = dL = (1) x (250) = 250 items

→ order is placed when inventory level = 250 items
Independent vs. Dependent Demand

Inventory policy is based on the type of demand

• Independent Demand
  – demand for a finished product

• Dependent Demand
  – demand for components parts or subassemblies
  – order quantities computed with Material Requirements Planning (MRP)
  – relationship between independent and dependent demand is shown in a bill of materials (BOM)
Bill of Materials

Figure 9.8 A simple bill of materials (BOM).
Managing Supply Chain Inventory

In addition to the quantitative models, there are a number of practical implications to consider:

• ABC Inventory Classification
• Practical Considerations of EOQ
• Measuring Inventory Performance
• Vendor Managed Inventory
ABC Inventory Classification

ABC system classifies inventory based on its degree of importance

Steps:

1. Determine annual usage or sales for each item
2. Determine % of total usage or sales for each item
3. Rank items from highest to lowest %
4. Classify items into groups:
   A: highest value, B: moderate value, C: least valuable
ABC Inventory Classification

**FIGURE 9.9** ABC classification of inventory.
Practical Considerations of EOQ

• Lumpy Demand
  – can use Periodic Order Quantity (POQ) when demand is not uniform

• EOQ Adjustments
  – total cost changes little on either side of the EOQ
    → managers can adjust to accommodate needs

• Capacity Constraints
  – storage capacity and costs should be considered when ordering large quantities
Measuring Inventory Performance

Common metrics for inventory:

- **Units**
  - # units available

- **Dollars**
  - dollars tied up in inventory

- **Weeks of Supply**
  - (avg. on-hand inventory) / (avg. weekly usage)

- **Inventory Turns**
  - (cost of good sold) / (avg. inventory value)
Average Inventory Example

Given a fixed-order quantity model with:
- Annual Demand (D) = 1,000 units
- Order Quantity (Q) = 250 units
- Safety Stock (SS) = 50 units

- **Average Inventory** = \(\frac{Q}{2} + SS\)
  = \(\frac{250}{2} + 50 = 175\) units

- **Inventory Turn** = \(\frac{D}{\frac{Q}{2} + SS}\)
  = \(\frac{1,000}{175} = 5.71\) turns per year
Vendor Managed Inventory (VMI)

VMI arrangements have the vendor responsible for managing the inventory located at a customer’s facility

The vendor:
- stocks inventory
- places replenishment orders
- arranges the display
- typically owns inventory until purchased
- is required to work closely with customer
Review

1. Reasons to carry inventory include protecting against lead time demand, maintaining independence, buffering against uncertainty.

2. Inventory types include: cycle stock, safety stock, anticipation, pipeline, and MRO.

3. 3 inventory costs: holding, ordering, & shortage.

4. a. Inventory systems answer: when to order and how much to order.
4. Two most common systems are: fixed-order quantity and fixed-time period.

5. Fixed-order quantity systems have a reorder point (ROP). The basic system utilizes the economic order quantity (EOQ), and when production feeds demand, it utilizes the economic production quantity (EPQ).

6. In fixed-time period systems the time between orders, T, is constant, and the order quantity varies. Orders bring the IP to a target level, R.
Review Continued

7. Independent demand is for a finished product and dependent demand is for components.

8. ABC classification defines the degree of importance for inventory.

9. The most common ways to measure inventory are in units, dollars, weeks of supply, and inventory returns.

10. Vendor managed inventory (VMI) is where the vendor is responsible for the inventory located at a customer’s facility.