Chapter 6

Inventory Management

Operations Management

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Agenda

- **Advantages and Disadvantages of Keeping Inventory**
- Cycle Inventory
- Safety Inventory

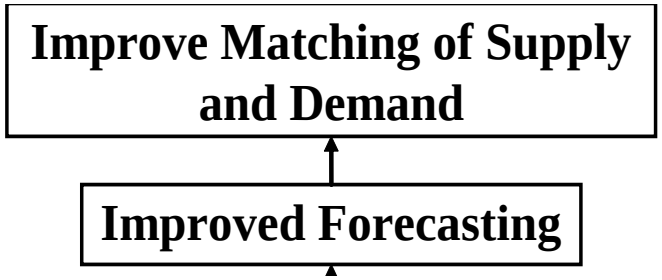
The downsides of keeping inventory

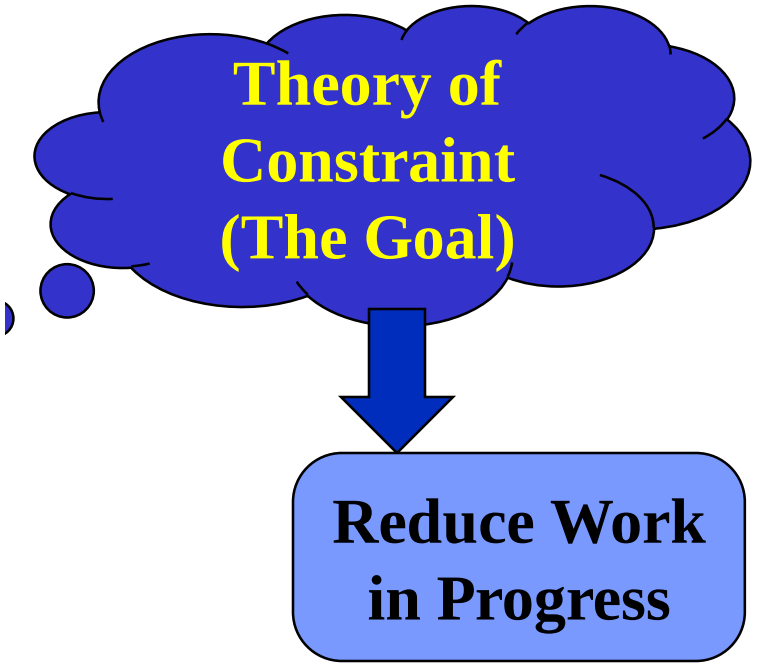
- What are the downsides of keeping inventory?
  - Inventory Cost
    - Cost of space, handling, air-conditioning, …
    - Financial cost
  - Product expiration dates
  - Hiding problems
  - Increased cycle time
  - …

Why do we keep inventory?

- Work-in-progress
- Cycle inventory
  - Average amount of inventory used to satisfy demand between shipments
- Safety inventory (Protection against randomness)
  - inventory held in case demand exceeds expectations
- Seasonal inventory
  - inventory built up to counter predictable variability in demand

Role of Inventory in Operations





Why do we keep inventory?

- Work-in-progress
- Cycle inventory
  - **Trade off**: Inventory cost versus ordering cost
- Safety inventory (Protection against randomness)
  - **Trade off**: inventory cost versus cost of losing sales
- Seasonal inventory
  - **Trade off**: Inventory cost versus production capacity cost

Agenda

- Advantages and Disadvantages of Keeping Inventory
- **Cycle Inventory**
- Safety Inventory

Cycle Inventory

- **Lot, or batch size:**

  Quantity that a supply chain stage either produces or orders at a given time

  Why do we build or purchase in batches?

- **Cycle inventory:**

  Average inventory that builds up in the supply chain.

Cycle Inventory

- Inventory holding cost
  - Cost of capital
  - Obsolescence cost
  - Handling cost
  - Occupancy cost
  - Miscellaneous costs
- Order cost
  - Buyer time
  - Transportation costs
  - Receiving costs
  - Other costs

Cycle Inventory

- Primary role of cycle inventory is to allow different stages to purchase product in lot sizes that **minimize** the sum of ordering, and holding costs

- Ideally, cycle inventory decisions should consider costs across the **entire supply chain**, but …

Fixed Costs: Optimal Lot Size and Reorder Interval (EOQ)

S: Setup or Order Cost

C: Cost per unit

h: Holding cost per year as a fraction of product cost

H: Holding cost per unit per year=hC

Q: Lot Size

Fixed Costs: Optimal Lot Size and Reorder Interval (EOQ)

D: Annual demand

S: Setup or Order Cost

C: Cost per unit

h: Holding cost per year as a fraction of product cost

Q: Lot Size

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

Cycle Inventory Example

- Demand for the Deskpro computer at Best Buy is 1,000 units per month. Best Buy incurs a fixed order placement, transportation and receiving cost of $4,000 each time an order is placed. Each computer costs Best Buy $500 and the retailer has a holding cost of 20% (annual).

- Evaluate the number of computers that the store manager should order in each replenishment lot.

Cycle Inventory Example

Demand, D = 12,000 computers per year

d = 1000 computers/month

Unit cost, C = $500

Holding cost fraction, h = 0.2

Fixed cost, S = $4,000/order

Q* = Sqrt[(2)(12000)(4000)/(0.2)(500)] = 980 computers

$$Q^* = \sqrt{\frac{2DS}{hC}} = \sqrt{\frac{2*12000*4000}{0.2*500}} = 980$$

Agenda

- Advantages and Disadvantages of Keeping Inventory
- Cycle Inventory
- **Safety Inventory**

Why do we keep safety inventory?

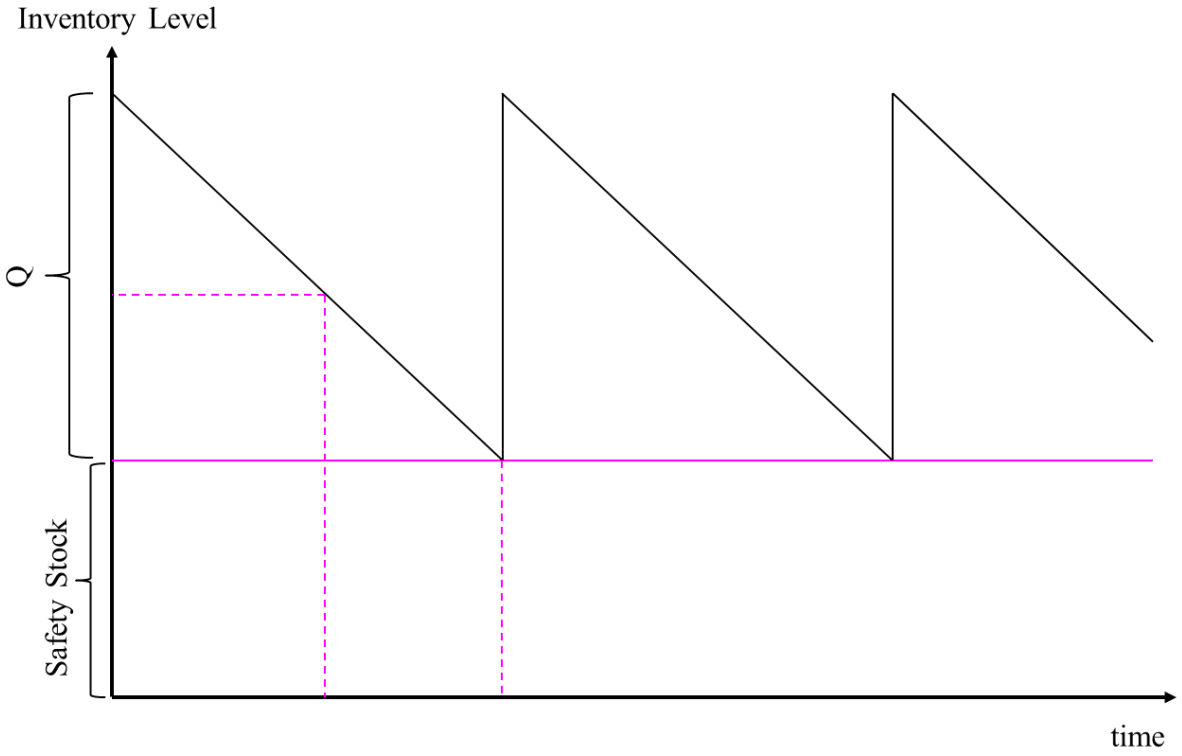
- Forecasts are rarely completely accurate
- If average demand is 1000 units per week, then half the time actual demand will be greater than 1000, and half the time actual demand will be less than 1000;
- what happens when actual demand is greater than 1000?

- **Safety inventory**: Inventory carried for the purpose of satisfying demand that exceeds the amount forecasted in a given period

Role of Safety Inventory

- Average inventory:

  cycle inventory + safety inventory



Role of Safety Inventory

- What happens if we raise the level of safety inventory?
  - higher levels of product availability and customer service
  - Higher levels of average inventory and therefore higher holding costs

Determining the Appropriate Level of Safety Inventory

- Appropriate level of safety inventory is determined by:
  - supply or demand uncertainty
  - desired level of product availability
- Higher levels of uncertainty require …
- Higher levels of desired product availability require …

Measuring Demand Uncertainty

- Notation:

  D = Average demand per period

  σ_D = standard deviation of demand per period

  L = lead time: time between when an order is placed and when it is received

- Uncertainty of demand during lead time is what is important

Measuring Product Availability

- Product fill rate (fr):

  fraction of demand that is satisfied from product in inventory

- Order fill rate:

  fraction of orders that are filled from available inventory

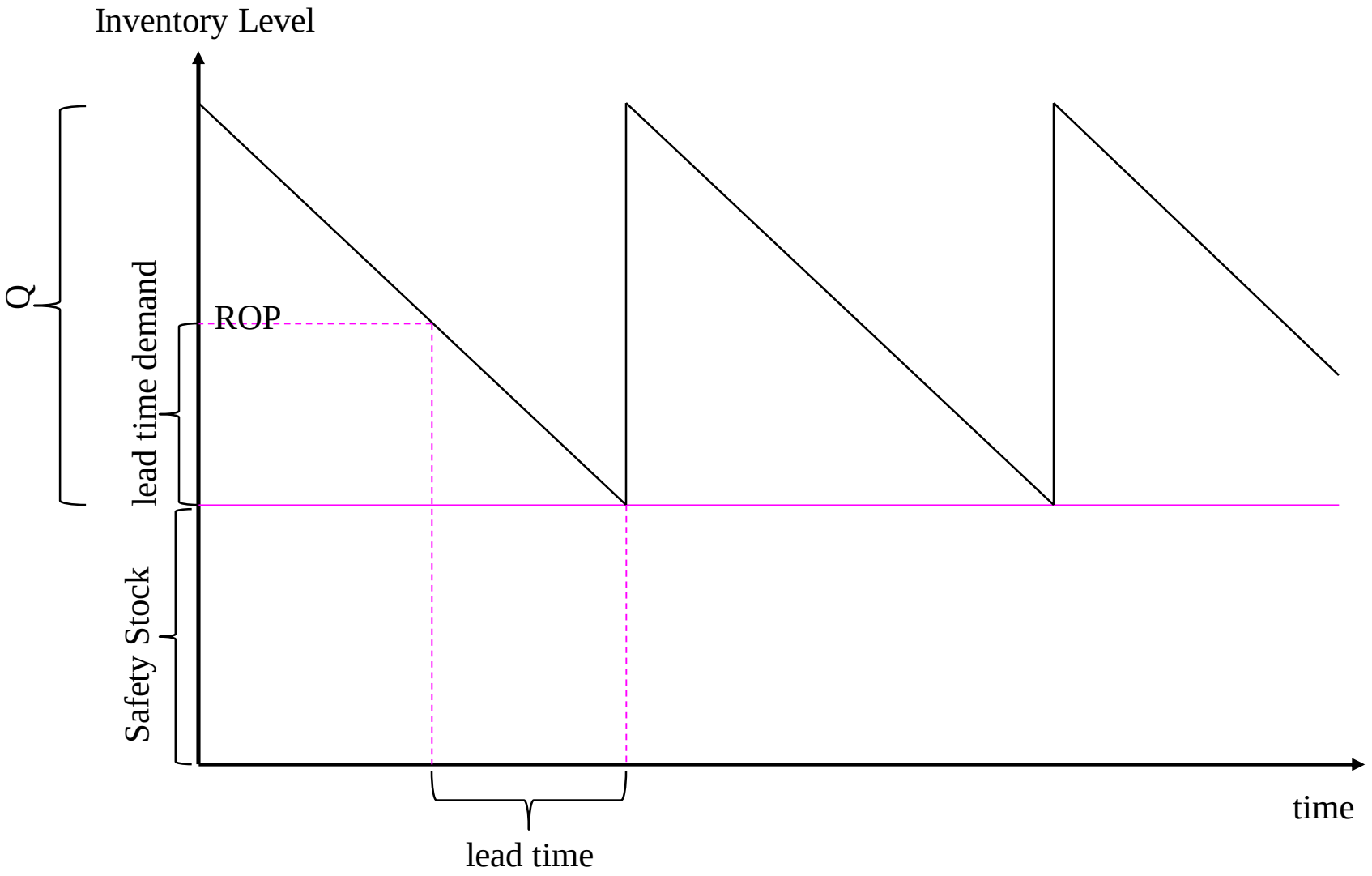
- Cycle service level:

  fraction of replenishment cycles that end with all customer demand met

Replenishment Policies

- Replenishment policy:
  - decisions regarding **when** to reorder and **how much** to reorder
- Continuous review:
  - inventory is continuously monitored and an order of size Q is placed when the inventory level reaches the reorder point **ROP**
- Periodic review:
  - inventory is checked at regular (periodic) intervals and an order is placed to raise the inventory to a specified threshold (the “order-up-to” level)

Continuous Review Policy: Safety Inventory and Cycle Service Level



Continuous Review Policy: Safety Inventory and Cycle Service Level

- L: Lead time for replenishment
- D: Average demand per unit time
- σ_D: Standard deviation of demand per period
- D_L: Mean demand during lead time
- σ_L: Standard deviation of demand during lead time
- CSL: Cycle service level
- ss: Safety inventory
- ROP: Reorder point

$$D_L = DL$$

$$\sigma_L = \sqrt{L}\,\sigma_D$$

$$ss = F_S^{-1}(CSL) \times \sigma_L$$

$$ROP = D_L + ss$$

$$CSL = F(ROP, D_L, \sigma_L)$$

$$Average\ Inventory = Q/2 + ss$$

Example 1: Estimating Safety Inventory (Continuous Review Policy)

$D = 2{,}500$/week; $\sigma_D = 500$

$L = 2$ weeks; $Q = 10{,}000$; $ROP = 6{,}000$

$D_L = D$L =

ss =

Cycle inventory =

Average Inventory =

Average Flow Time = Avg inventory / throughput =
weeks

Example 2: Estimating Cycle Service Level (Continuous Review Policy)

$D = 2{,}500$/week; $\sigma_{D=} 500$

$L = 2$ weeks; $Q = 10{,}000$; $ROP = 6{,}000$

$$\sigma_L = \sigma_R \sqrt{L} = (500)\sqrt{2} = 707$$

Cycle service level, $CSL = F(D_L + ss, D_L, \sigma_L) =$

$= \text{NORMDIST}(D_L + ss, D_L, \sigma_L) = \text{NORMDIST}(6000,5000,707,1)$

= 0.92 (This value can also be determined from a Normal probability distribution table)

Impact of Required Product Availability and Uncertainty on Safety Inventory

- Managerial levers to reduce safety inventory without reducing product availability
  - reduce supplier lead time, L (better relationships with suppliers)
  - reduce uncertainty in demand, σ_L (better forecasts, better information collection and use)