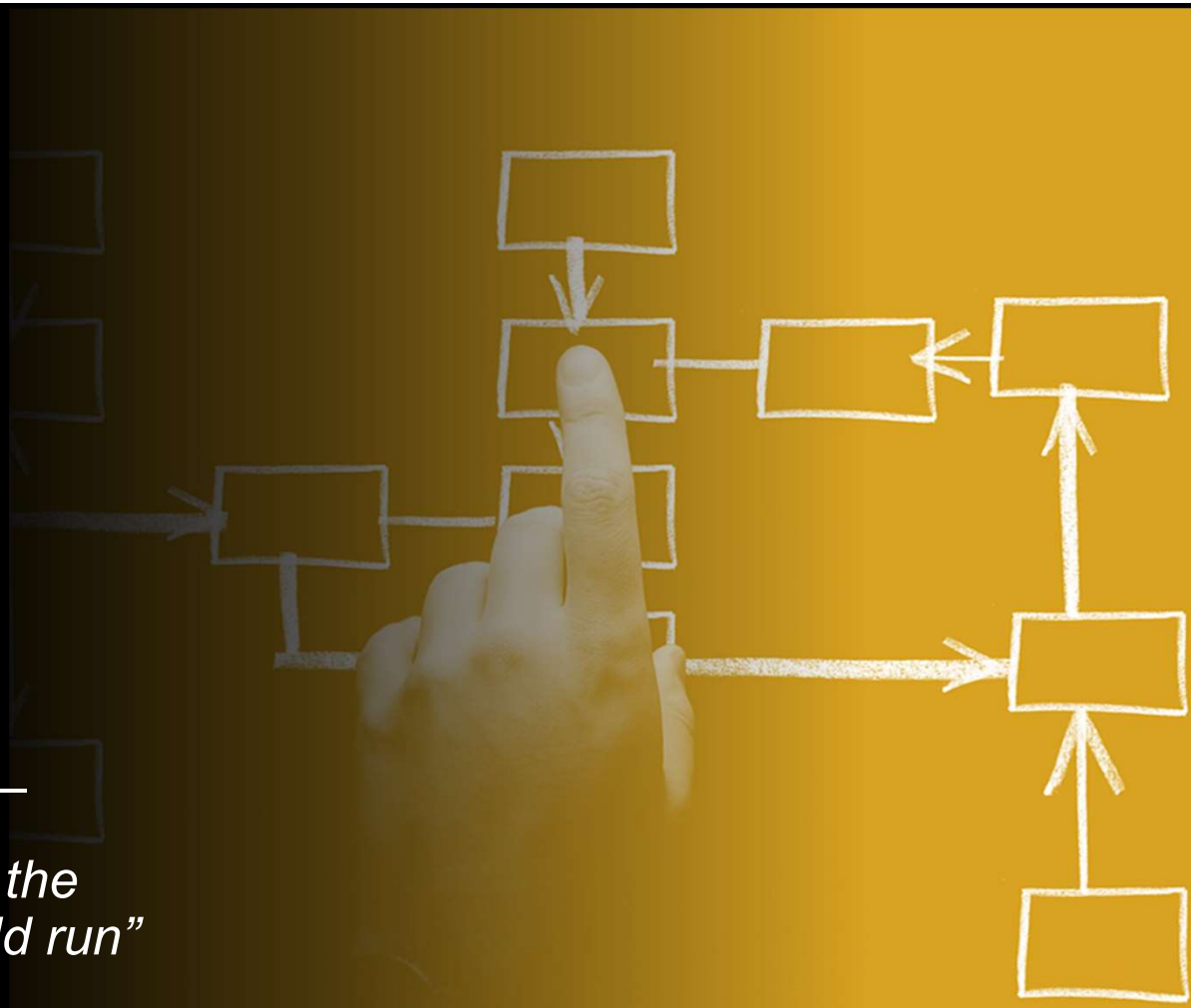
Operations Management **MLI21C617**

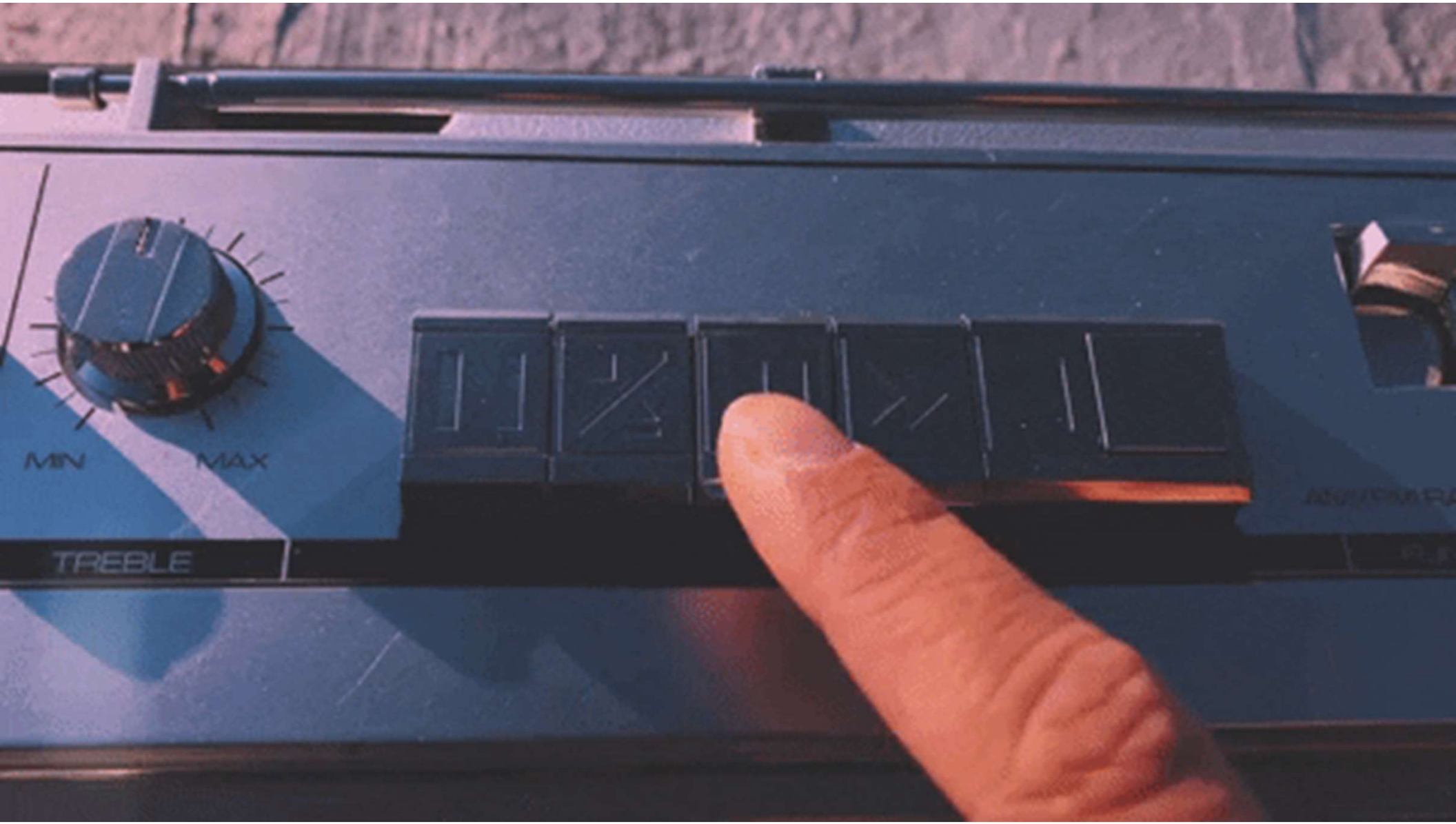


"Operations may not run the world, but it makes the world run"

Lecturer: Misa Bakajic

Spring 2024

LECTURE 8 Inventory Management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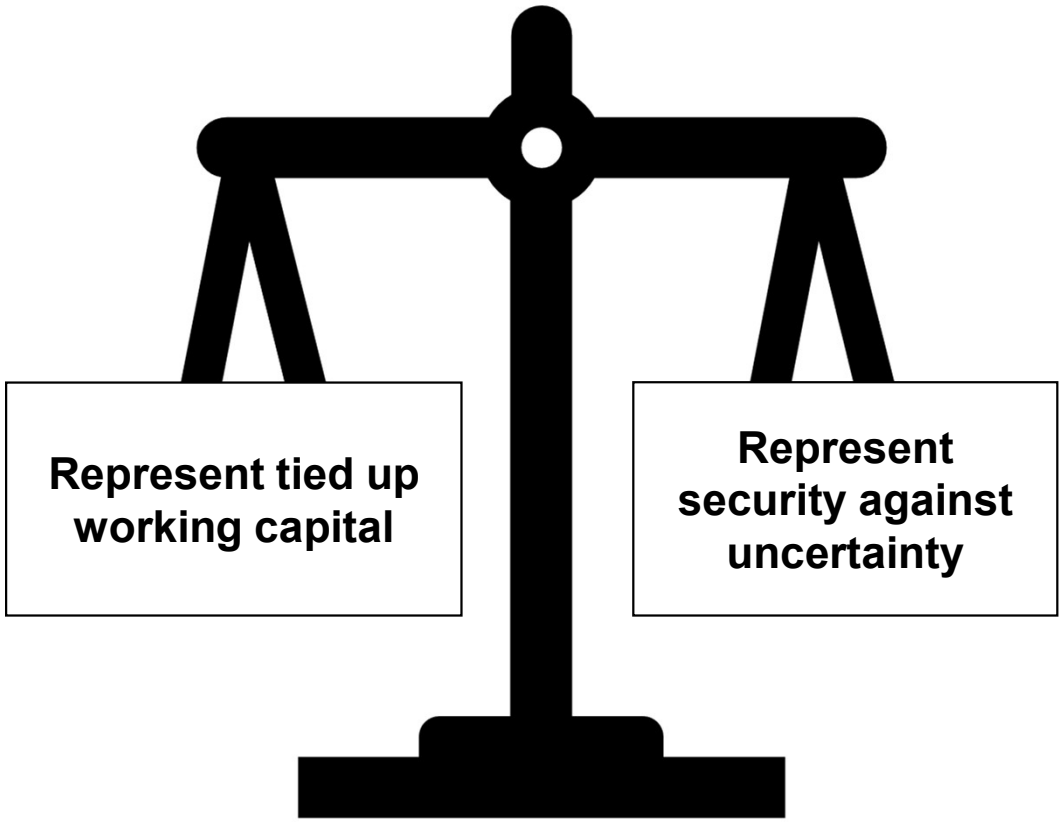
Recap

1. Supply chain management focuses on serving needs of customer
2. Containers are essential for global trade
3. Supply chain management is all about relationships
4. Supply chain management balances sourcing/procurement and demand
5. Bullwhip effect is the mismatch between inventory and demand

The dual nature of inventories



Inventory as a Buffer for supply and demand

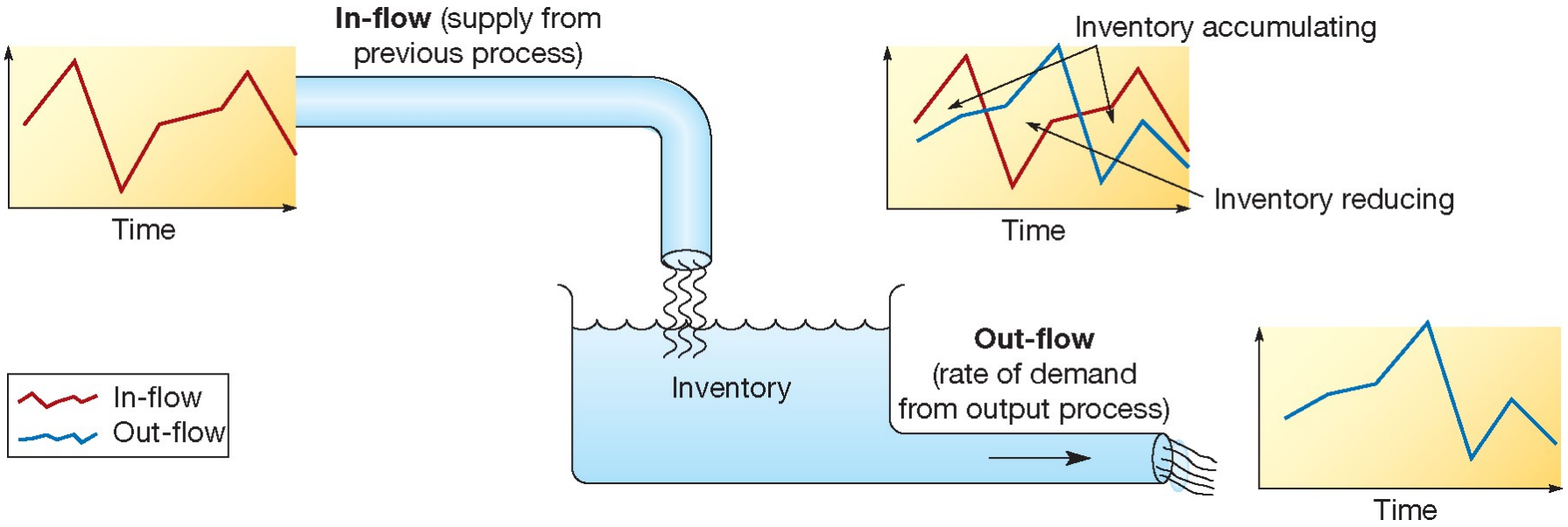


Figure 13.2

Working definition of inventory

"the accumulation of materials, customers or information as they flow through processes or networks" (Slack at al. 2022)

EXAMPLES OF INVENTORY

Raw materials	**Safety Stock**	**Work-in-Progress (WIP)**	**Finished goods**
Maintenance, repair, and operations (MRO) Inventory	**Anticipation inventory**	**Pipeline inventory***	**Merchandise**

A!

In geographically dispersed supply networks pipeline inventory can be significant

Inventory turn rate

- Inventory turnover shows how many times inventory replenishes relative to cost of goods sold (COGS) in each period
- Shows how efficiently a company uses its inventory
- Lower inventory turnover ratio may be a sign of weak sales or excess inventory
- Higher ratio signals strong sales but may also indicate inadequate inventory stocking
- Useful for comparing similar companies (e.g. Zara vs H&M)

Inventory Turnover Rate = Cost of Goods Sold (COGS) / Average Inventory

Inventory Turn - Problem

An investor is looking at three athletics companies and trying to figure out their inventory management efficiency. They gathered the information below and wish to calculate their inventory turnover.

- **Company A (Sport Flex):**
  - Cost of Goods Sold (COGS) for year: $1,200,000
  - Beginning Inventory: $200,000
  - Ending Inventory: $300,000
- **Company B (Swift Sneakers):**
  - COGS for the year: $800,000
  - Beginning Inventory: $100,000
  - Ending Inventory: $150,000
- **Company C (Peak Performance):**
  - COGS for the year: $1,500,000
  - Beginning Inventory: $500,000
  - Ending Inventory: $400,000

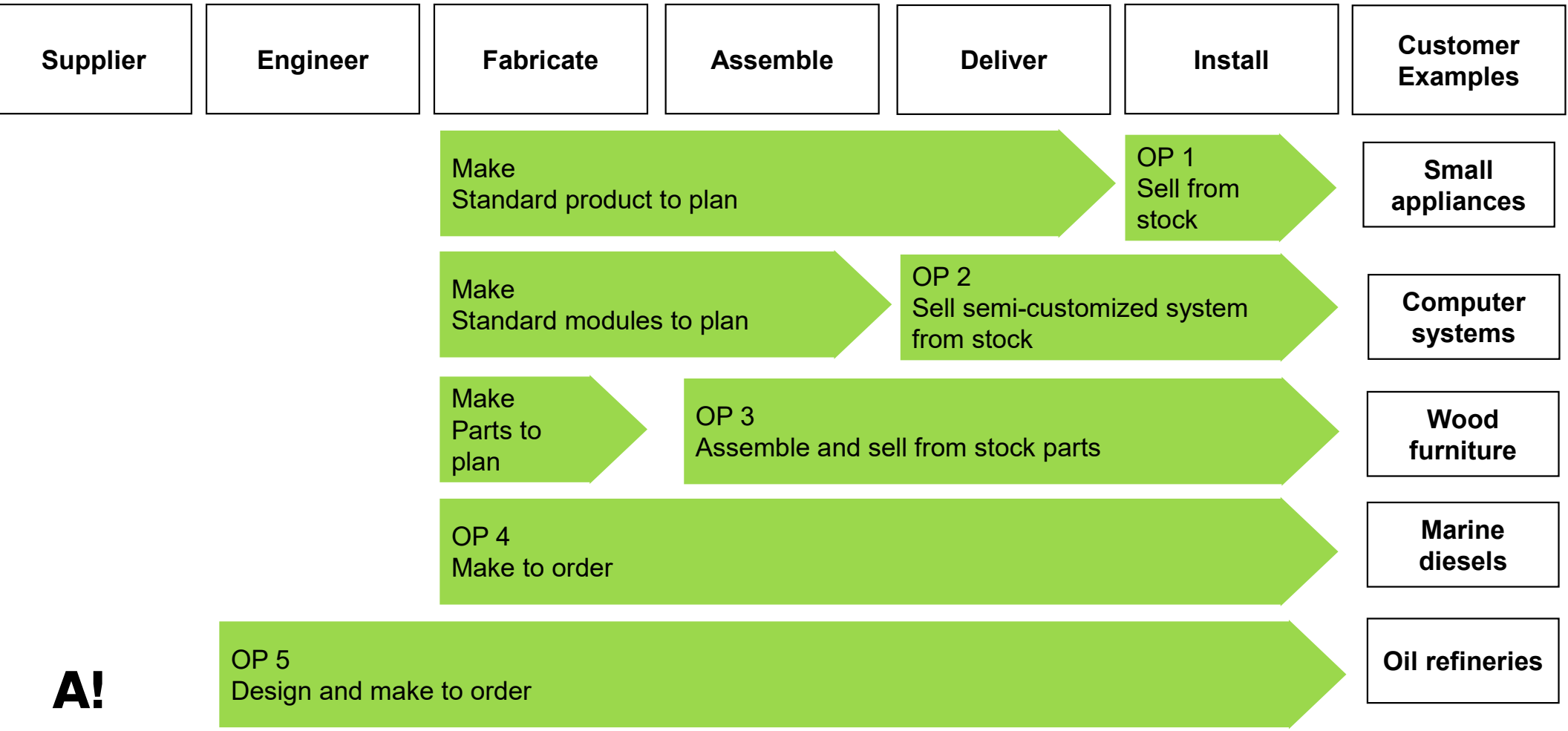
Step 1: Calculate Average Inventory:
We can use simple average method for this example:
Avg. Inventory = (Beginning Inventory + Ending Inventory) / 2
Avg Inventory = ($200,000 + $300,000) / 2
Average Inventory = $250,000

Step 2: Calculate Inventory Turnover Rate:
Inventory Turnover Rate = COGS / Average Inventory
Inventory Turnover Rate = $1,200,000 / $250,000
Inventory Turnover Rate = 4.8

Company B (Swift Sneakers):
1.Avg Inventory = ($100,000 + $150,000) / 2 = $125,000
2.Inventory Turnover Rate = $800,000 / $125,000 = 6.4

Company C (Peak Performance):
1.Avg Inventory = ($500,000 + $400,000) / 2 = $450,000
2.Inventory Turnover Rate = $1,500,000 / $450,000 = 3.33

Order penetration point



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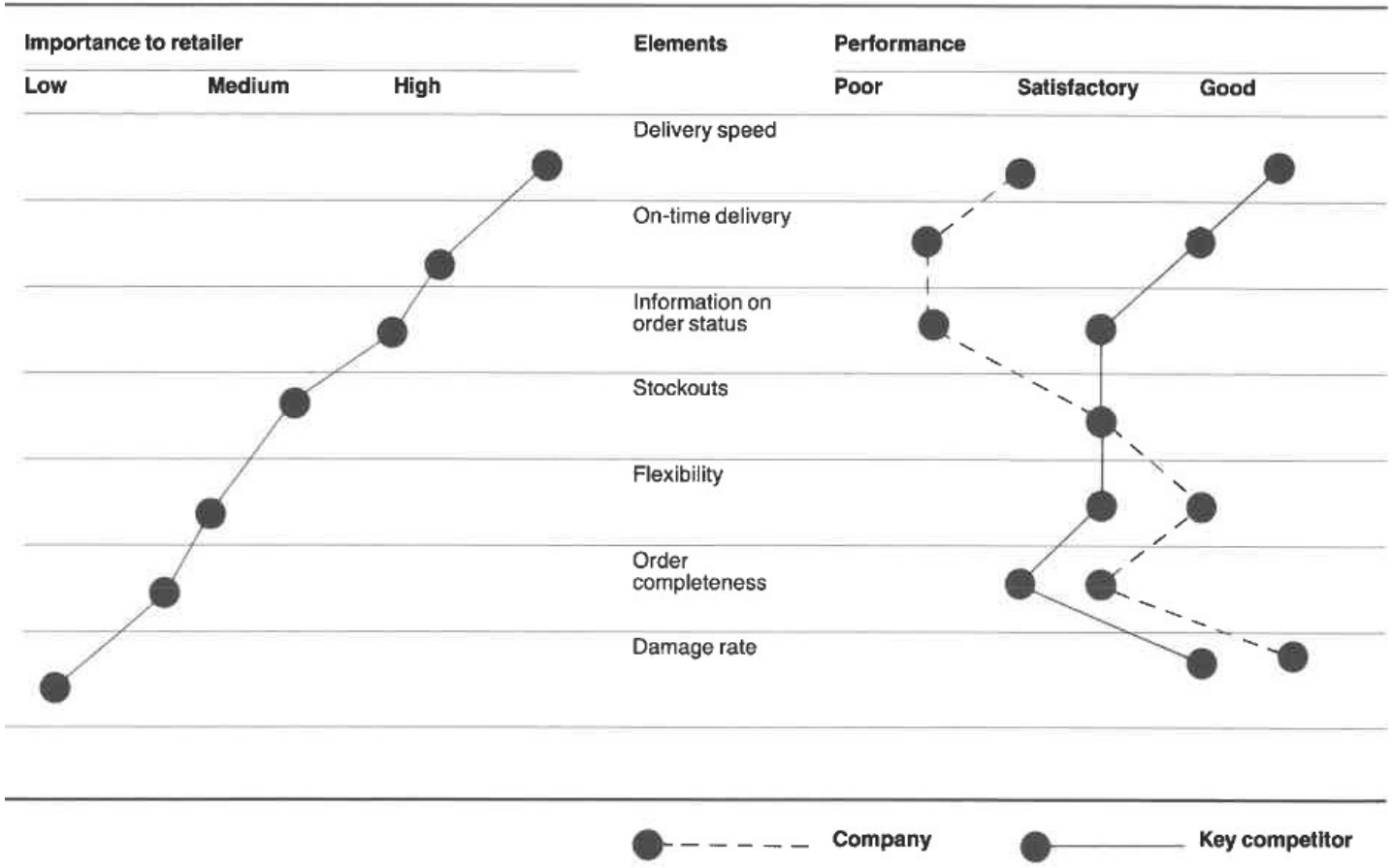
Sharman, G., 1984. The rediscovery of logistics. *Harvard business review*, *62*(5).

Customer service analysis for a consumer product



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Sharman, G., 1984. The rediscovery of logistics. *Harvard business review*, *62*(5).

Types of inventories

	INVENTORIES		
Process , operation, or supply network	**Physical Inventories**	**Queues of Customers**	**Information in Databases**
Hotel	Food items, drinks, toilet items, etc.	At check-in and check-out	Customer details, loyalty card holders, catering suppliers
Hospital	Dressings, disposable equipment, blood	Patients on waiting list, patients in beds prior to surgery, recovery wards	Patient medical records
Credit card application process	Blank cards, statements	Customers waiting on the phone	Customer's credit and other personal info
Computer manufacturer	Components for assembly, packaging, finished goods	Customers waiting for delivery of their computer	Customer shipping details, supplier information

Inventory impact on return on assets

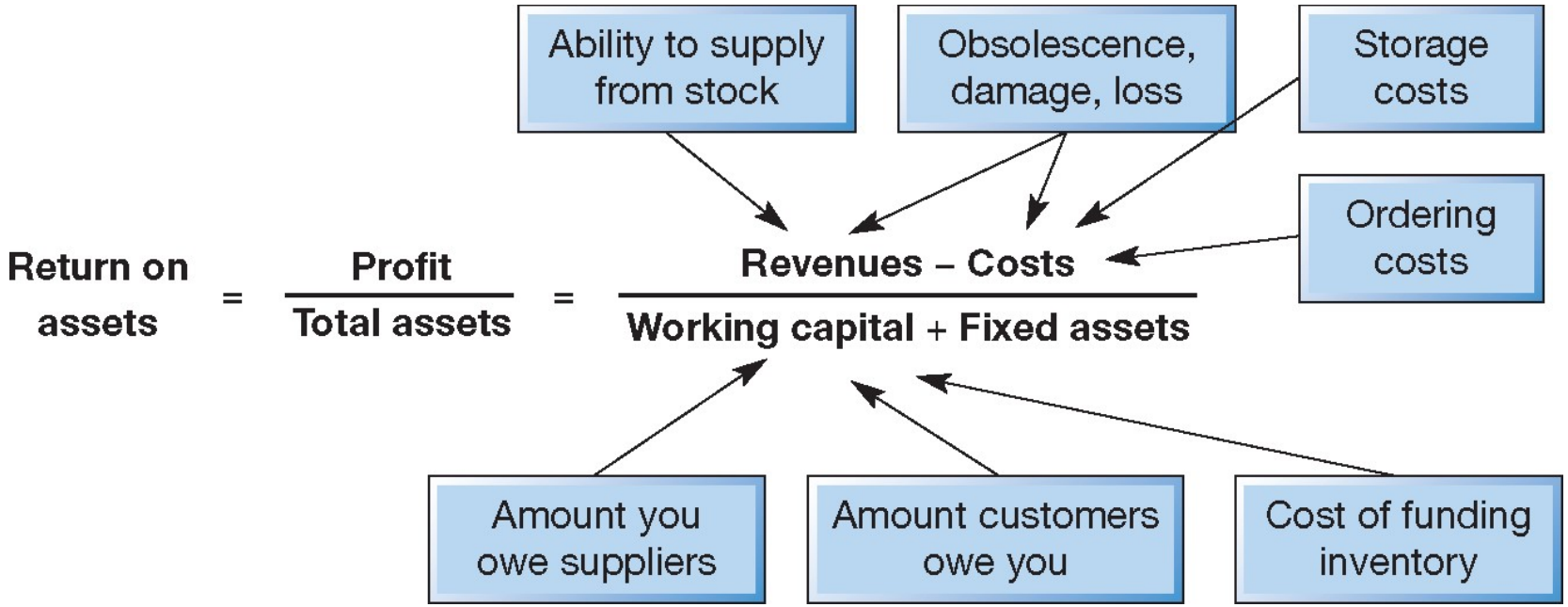

Figure 13.4

Cycle inventory: Example of a bakery

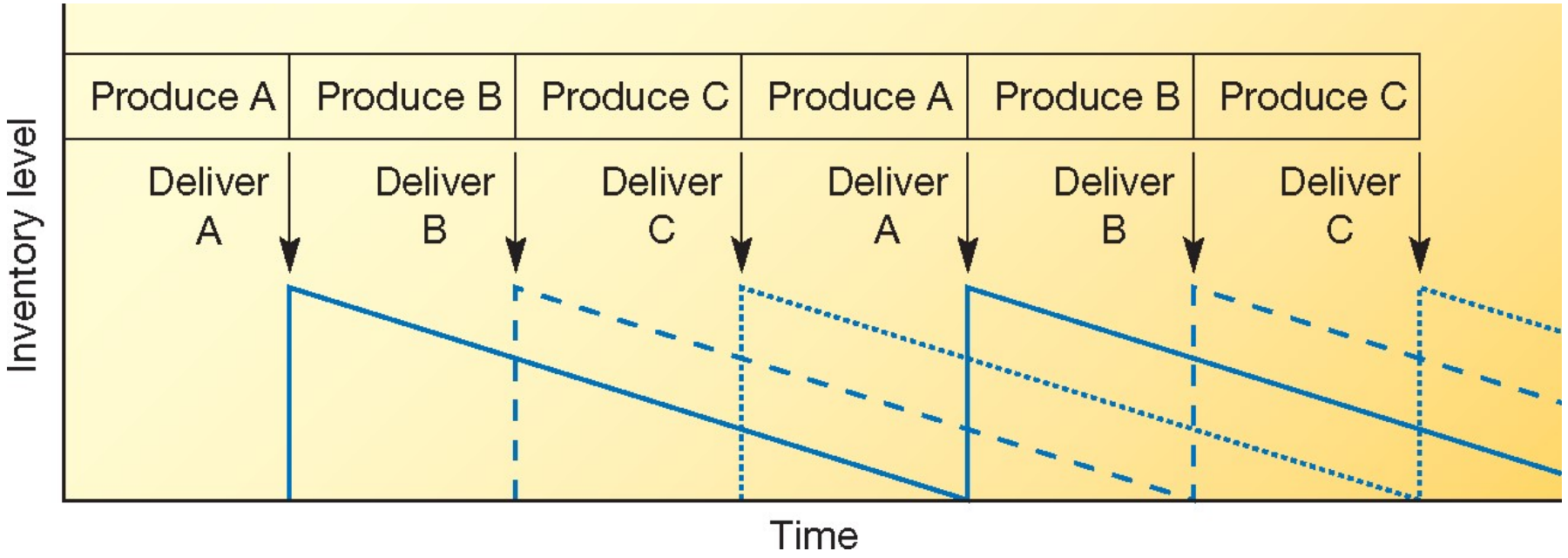

Figure 13.3

Average inventory

The typical amount or value of inventory a company holds over a specific period

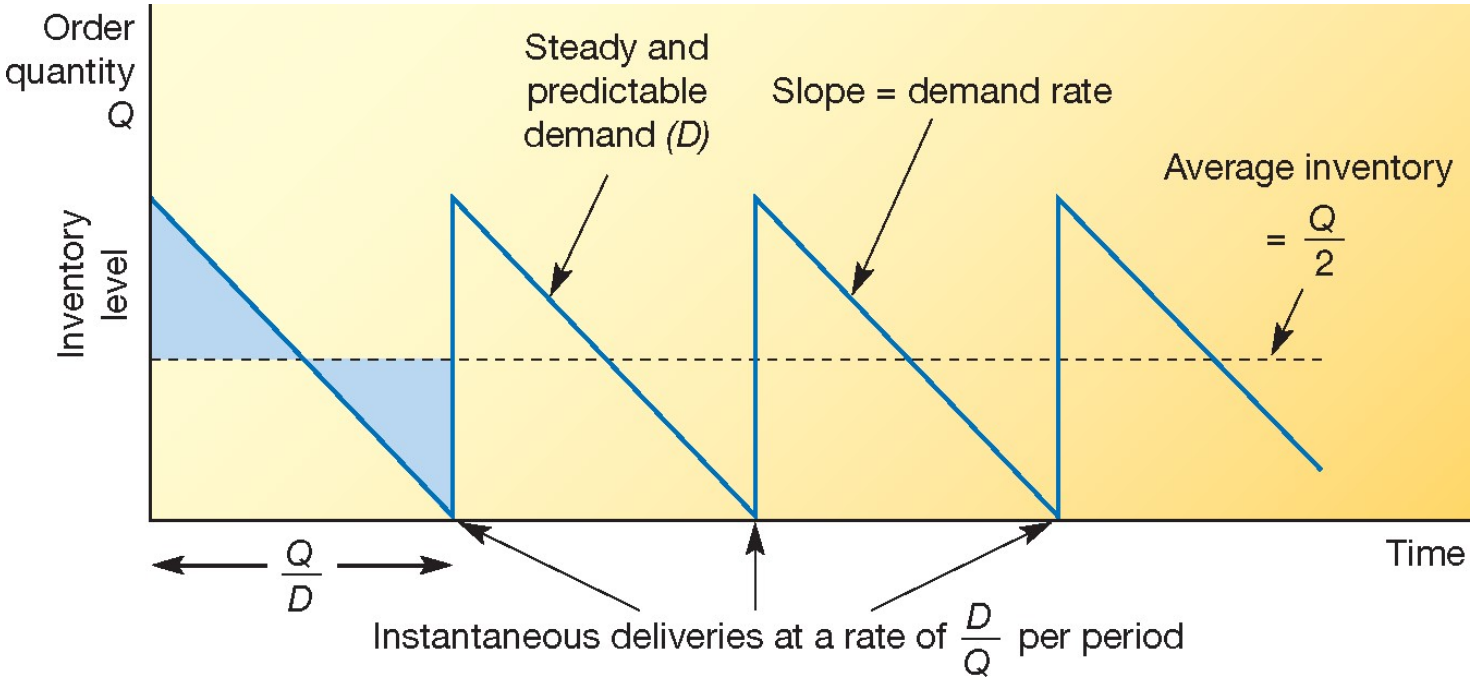

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Figure 13.5

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EOQ (Economic Order Quantity)

Holdings costs / Carrying costs

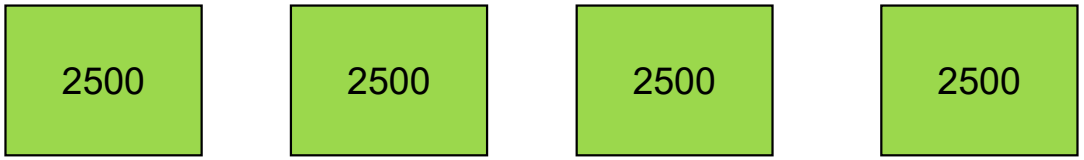
Expenses a business incurs for keeping unsold inventory in storage

Q: What expenses contribute to holding costs

Batch quantity options

Large order to satisfy a long interval of demand

Smaller orders to satisfy short intervals of demand



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Order costs

Expenses associated with placing and receiving new inventory from suppliers and can be fixed or variable

Fixed order costs example: Warehouse capita costs

Variable order costs example: Delivery of single order to location

Two alternative inventory plans with different order quantities (Q)

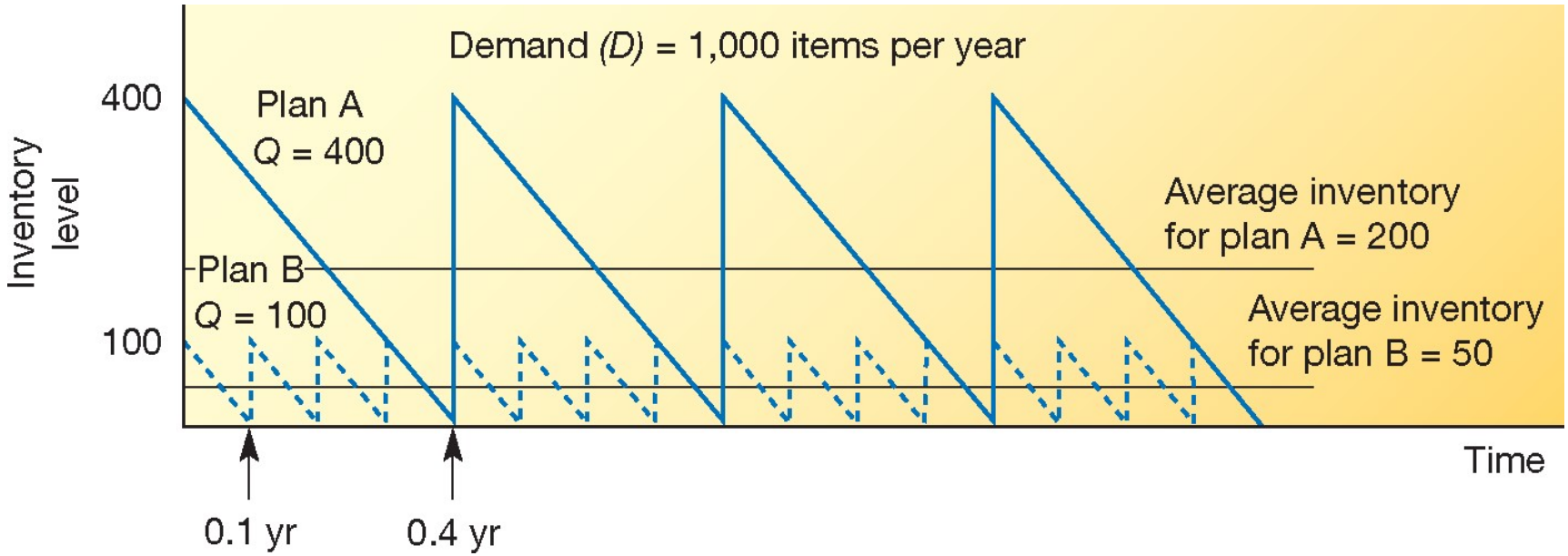

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Figure 13.6

Economic Order Quantity (EOQ)

- Minimize the sum of inventory holding & ordering costs
- Inventory holding costs: 0.5 * D * c_h
- Ordering costs: D/Q * c_o
- Total cost = D/Q * c_o + 0.5 * D * c_h
- We get EOQ through differentiating total cost …
- Therefore,

$$EOQ = \sqrt{\frac{2C_oD}{C_h}}$$

c_o = Order cost per order

D = Demand

c_h = Inventory holding cost per unit

Q = ordered quantity

A!

EOQ worked example

JLR uses about 60000 pairs of bumpers (front bumper and rear bumper) per year for Jaguar's models sold in the UK. The bumpers are ordered from a supplier in India. It costs €3.00 to keep one pair of bumpers in inventory for one month, and it costs €25 to place an order. A pair of bumpers costs €150.00.

What would be the EOQ for the number of pairs of bumpers?

$$EOQ = \sqrt{\frac{2C_oD}{C_h}}$$

Demand: D = 60000

Ordering cost: C_o = 25 (€/order)

Inventory holding cost: C_h = 12*3 = 36 (€/unit/year)

$$EOQ = \sqrt{\frac{2CoD}{C_h}} = \sqrt{\frac{2*25*60000}{36}} = 288.7 = 289 \text{ (pairs of bumpers).}$$

Answer: Every time JLR places an order, it should order <u>289 pairs of bumpers</u>

A!

EOQ worked example 2

Demand for a tricycle at Stockmann is 500 units per month. Stockmann incurs a fixed order placement cost of 10€ each time an order is placed. The tricycle costs 30€ to purchase from a supplier and has a holding cost of 20 percent. Evaluate the number of tricycles that the store manager should order in each replenishment lot?

$$EOQ = \sqrt{\frac{2C_oD}{C_h}}$$

D = 500 * 12 = 6000 (tricycles/year)

C_o = 10 (€/order)

C_h = 0.2 * 30 = 6.00 (€/unit/year)

$EOQ = \sqrt{\frac{2*10*6000}{6}} = \sqrt{20000}$ = 141.4 (tricycles)

Answer: Stockmann should order 141 tricycles each time it places an order.

A!

Graphical representation of economic order quantity (EOQ)

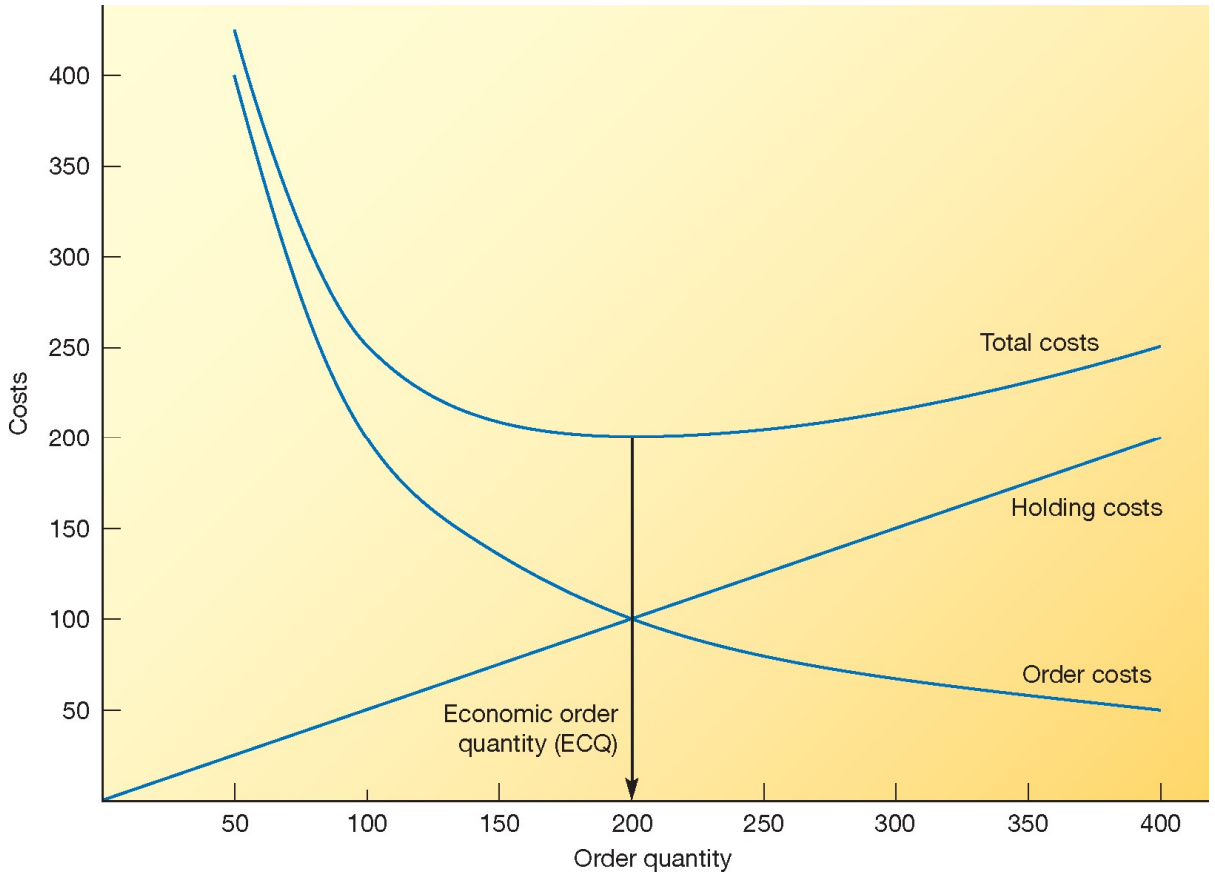

Figure 13.7

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Criticism of EOQ approach

1. Assumptions included in EOQ formula are simplistic
2. “Real” cost of stock in operations are not assumed in EOQ
3. EOQ are really descriptive should not be prescriptive
4. Should cost minimization be priority for inventory management?

True costs of stock holding impact on EOQ

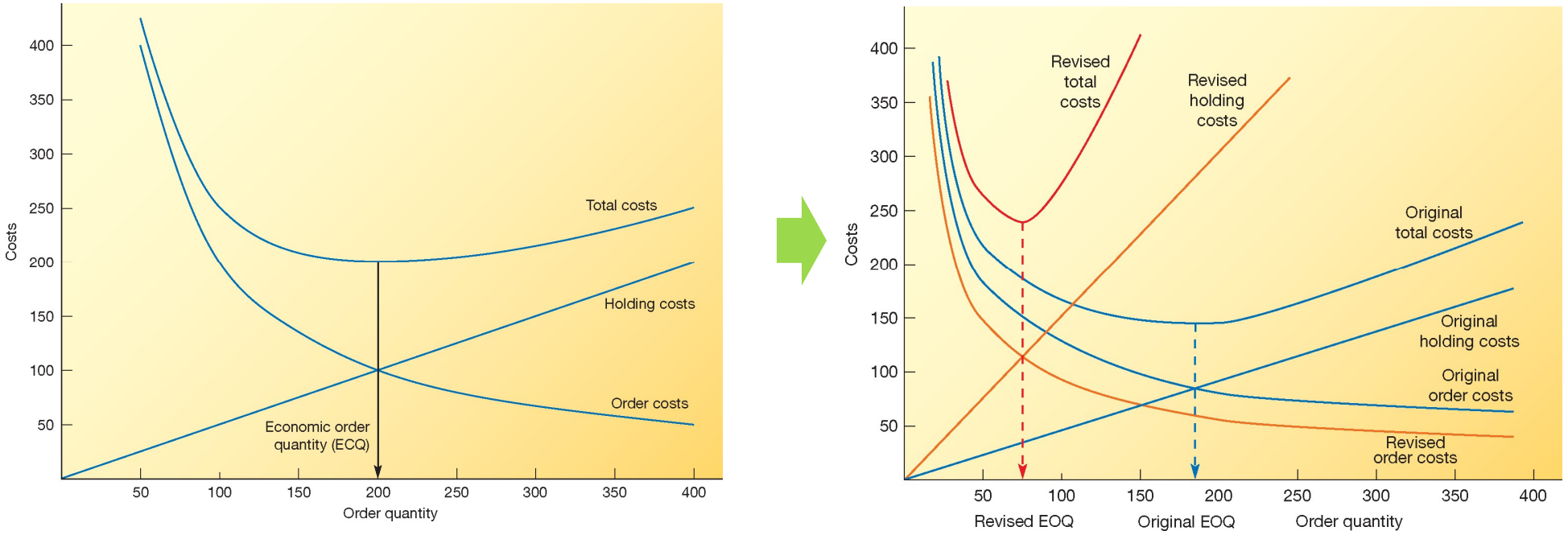

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Figure 13.9

Single Period Stochastic Inventory Models

These inventory models, e.g. Newsvendor, have the common objective of properly balancing the cost of:

Shortage vs. *Overage*

= having ordered too few products vs. having ordered too much

A!

The Nature of Uncertainty

- Let's represent demand as:

$$D = D_{deterministic} + D_{random}$$

- If the D_{random} is small compared to $D_{deterministic}$, deterministic inventory models will be satisfactory → use e.g. EOQ
  - Otherwise, randomness of demand must be explicitly accounted for in the model → stochastic models needed

A!

Newsvendor model summary

Demand Level	200	400	600	800
Probability	0.2	0.3	0.4	0.1
Order of 200	1000	1000	1000	1000
Order of 400	400	2000	2000	2000
Order of 600	-200	1400	3000	3000
Order of 800	-800	800	4000	4000

If we order 200 expected profit = (1000 * 0.2) + (1000 * 0.3) + (1000 * 0.4) + (1000 * 0.1) = 1000

If we order 400 expected profit = (400 * 0.2) + (2000 * 0.3) + (2000 * 0.4) + (2000 * 0.1) = 1680

If we order 600 expected profit = (-200 * 0.2) + (1400 * 0.3) + (3000 * 0.4) + (3000 * 0.1) = 1880

If we order 800 expected profit = (-800 * 0.2) + (800 * 0.3) + (4000 * 0.4) + (3000 * 0.1) = 1440

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Timing of order placement

Re-order point (ROP)

ROP is a stock level trigger for replenishing inventory. It helps businesses avoid stockouts and optimize their ordering cycles. There are two main factors that influence the reorder point:

1. Lead Time: This is the time it takes for a new order to be placed and received. It includes factors like supplier processing time, shipping time, and any customs procedures.

2. Demand Rate: This refers to the average rate at which you sell the item.

Re-order level (ROL) and re-order point (ROP) are derived from the order lead time and demand rate

Simple ROP formula

ROP = (Average Daily Sales * Days of Average Lead Time) + Safety Stock

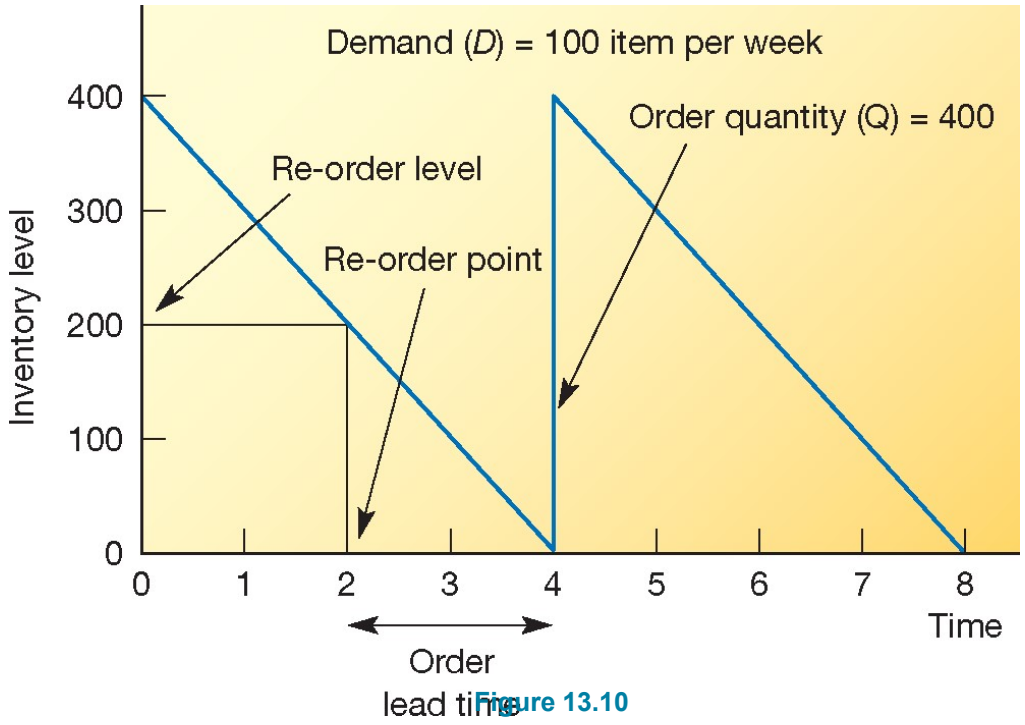

Figure 13.10

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Safety stock (s) helps to avoid stockouts when demand and/or order lead time are uncertain

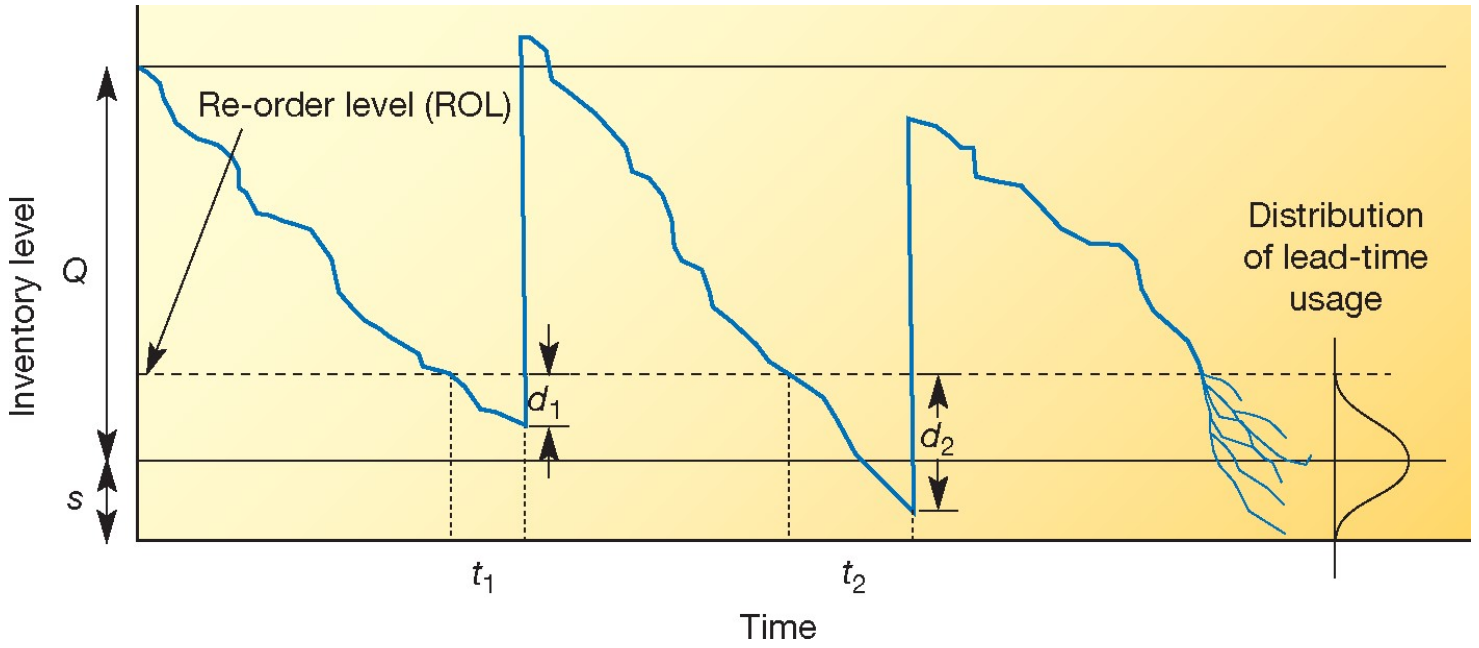

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Figure 13.11

Probability distributions for order lead time and demand rate combine to give the lead-time usage distribution

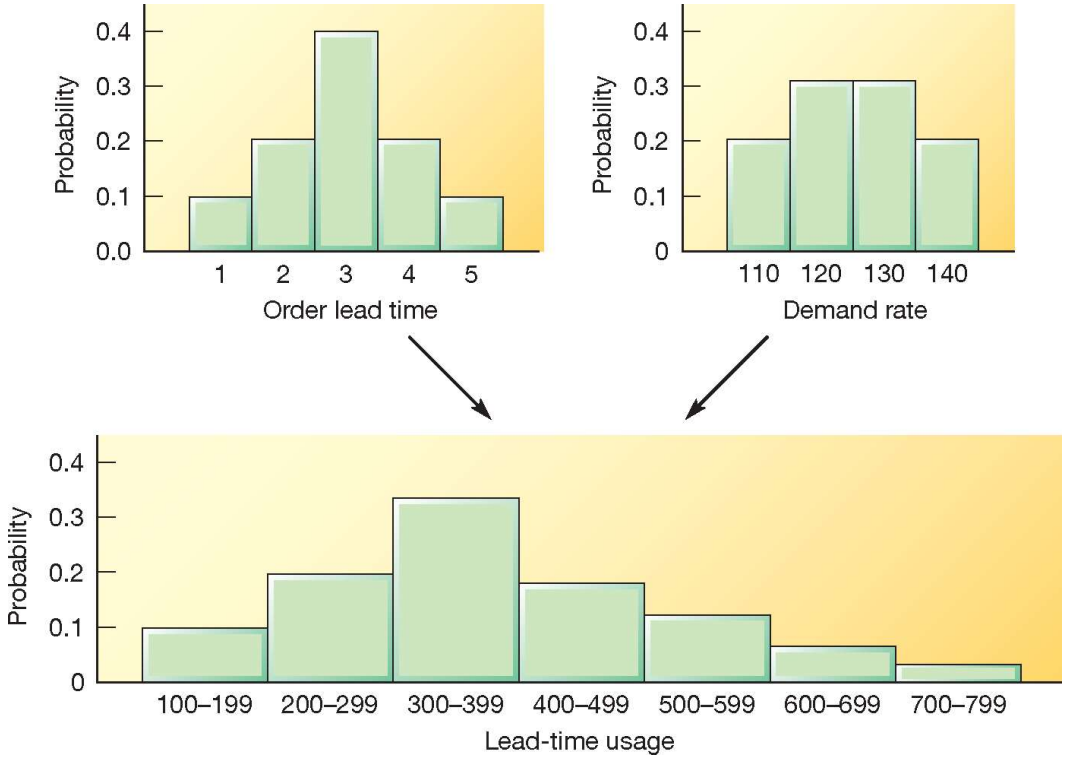

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Figure 13.12

A periodic review approach to order timing with probabilistic demand and lead time

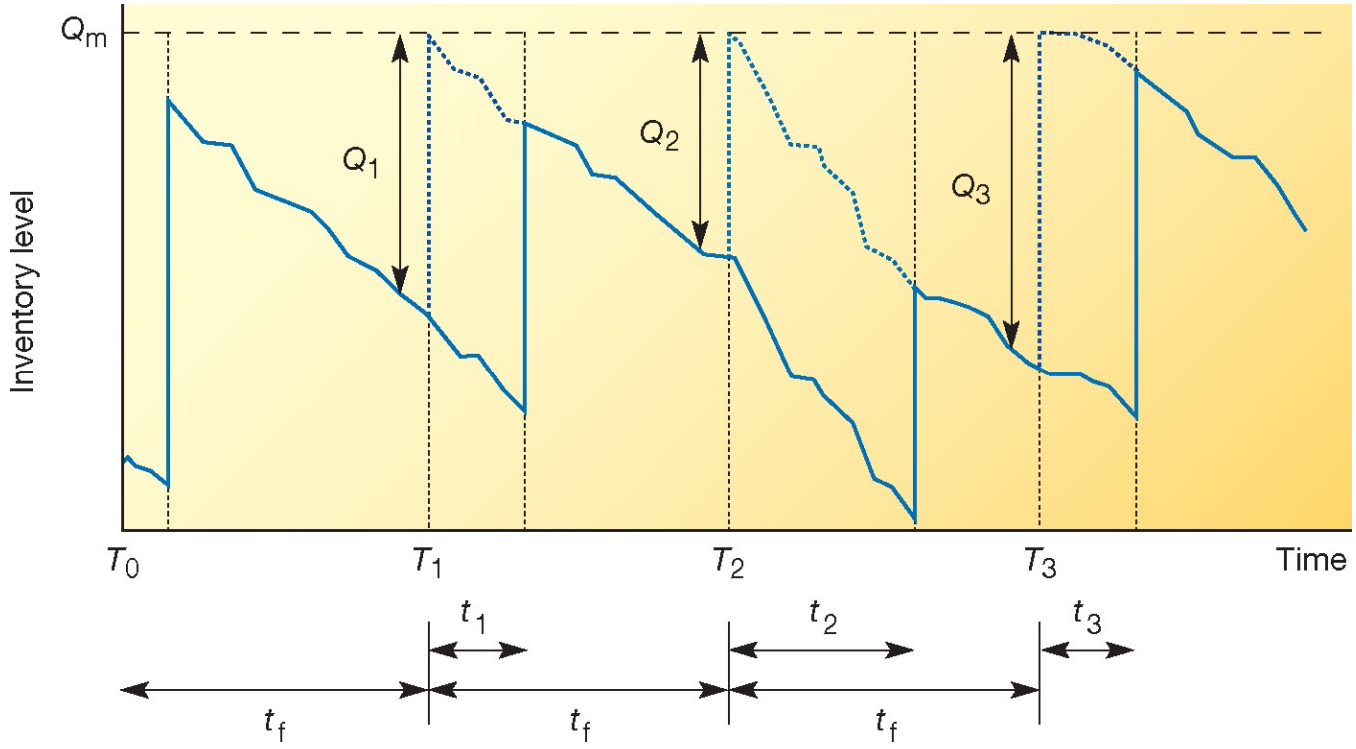

Figure 13.13

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The two-bin and three-bin systems of re-ordering

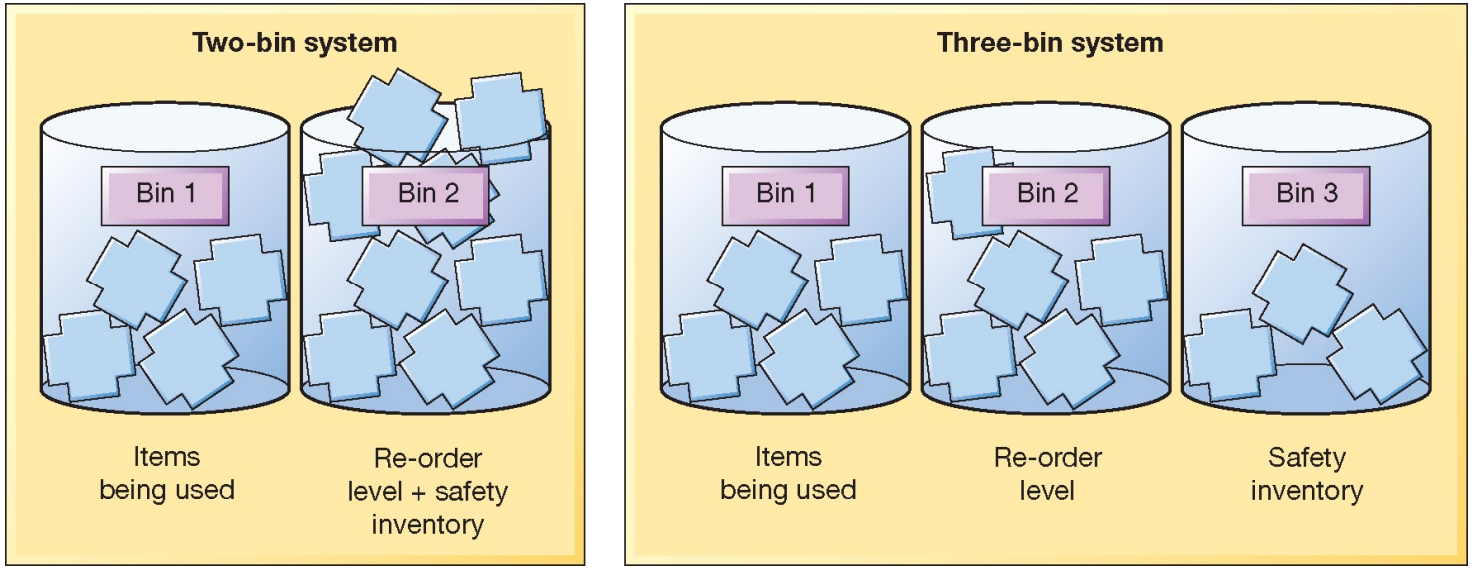

Figure 13.14

Inventory priorities using ABC system

Most of the value is generated from a small number of products (Pareto law of 20-80)

Firms therefore categorize inventory according to usage value

Usage value = usage rate * individual value

Class A items – high usage value

Class B items – medium usage value

Class C items – low usage value

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Pareto curve for items in a warehouse

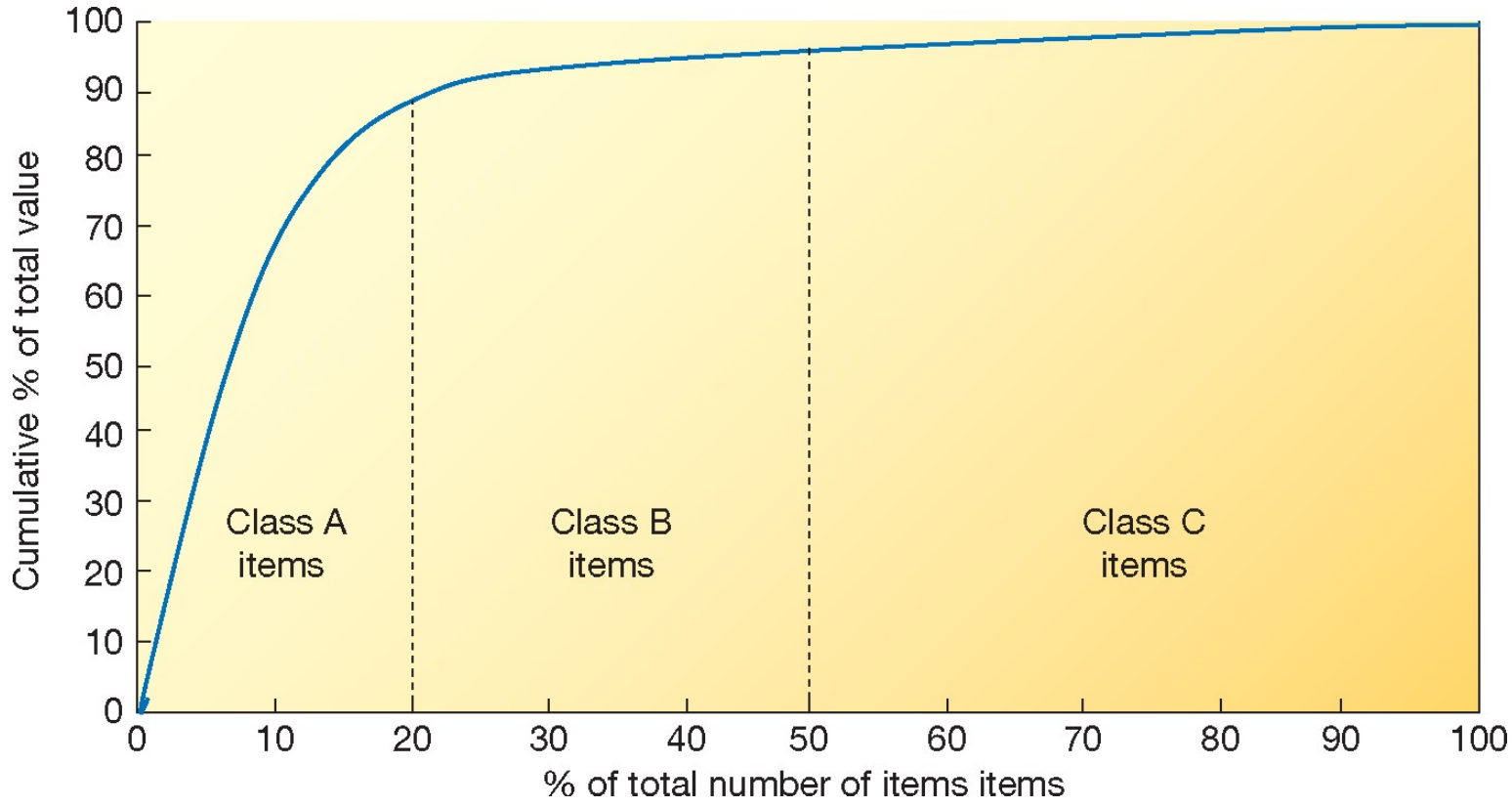

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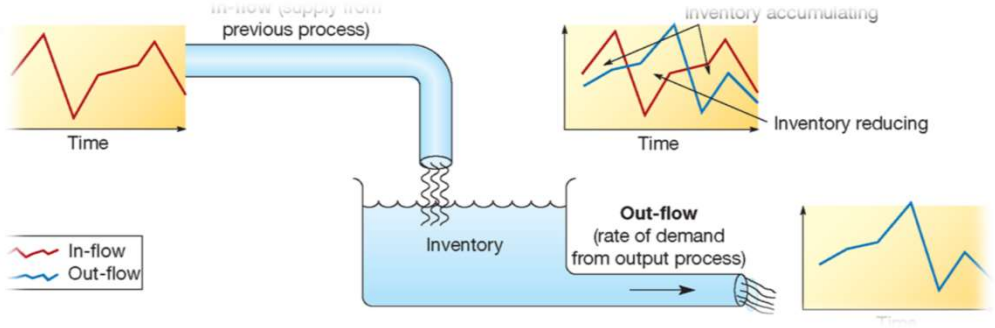
Figure 13.15

Perpetual inventory

Stocks should be updated every time a change occurs

New stock level = (Opening stock level + Receipts in - Dispatches out)



Inventory reality

System inventory may be different than actual inventory due to:

- Damage, theft, etc.
- Inaccurate data entry
- Wrong location on “the rack”
- Delays in inventory update

References

Slack, N., Brandon-Jones, A. & Burgess, N. 2022. *Operations management*. Tenth edition. Harlow, England ; New York: Pearson.

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