

Inventory Management

12

**PowerPoint presentation to accompany
Heizer, Render, Munson
Operations Management, Twelfth Edition
Principles of Operations Management, Tenth Edition**

PowerPoint slides by Jeff Heyl

Inventory Management

The objective of inventory management is to strike a balance between inventory investment and customer service

Importance of Inventory

- ▶ One of the most expensive assets of many companies representing as much as 50% of total invested capital
- ▶ Less inventory lowers costs but increases chances of running out
- ▶ More inventory raises costs but always keeps customers happy

Functions of Inventory

1. *To provide a selection of goods for anticipated demand and to separate the firm from fluctuations in demand*
2. *To decouple or separate various parts of the production process*
3. *To take advantage of quantity discounts*
4. *To hedge against inflation*

Types of Inventory

- ▶ **Raw material**
 - ▶ Purchased but not processed
- ▶ **Work-in-process (WIP)**
 - ▶ Undergone some change but not completed
 - ▶ A function of cycle time for a product
- ▶ **Maintenance/repair/operating (MRO)**
 - ▶ Necessary to keep machinery and processes productive
- ▶ **Finished goods**
 - ▶ Completed product awaiting shipment

The Material Flow Cycle

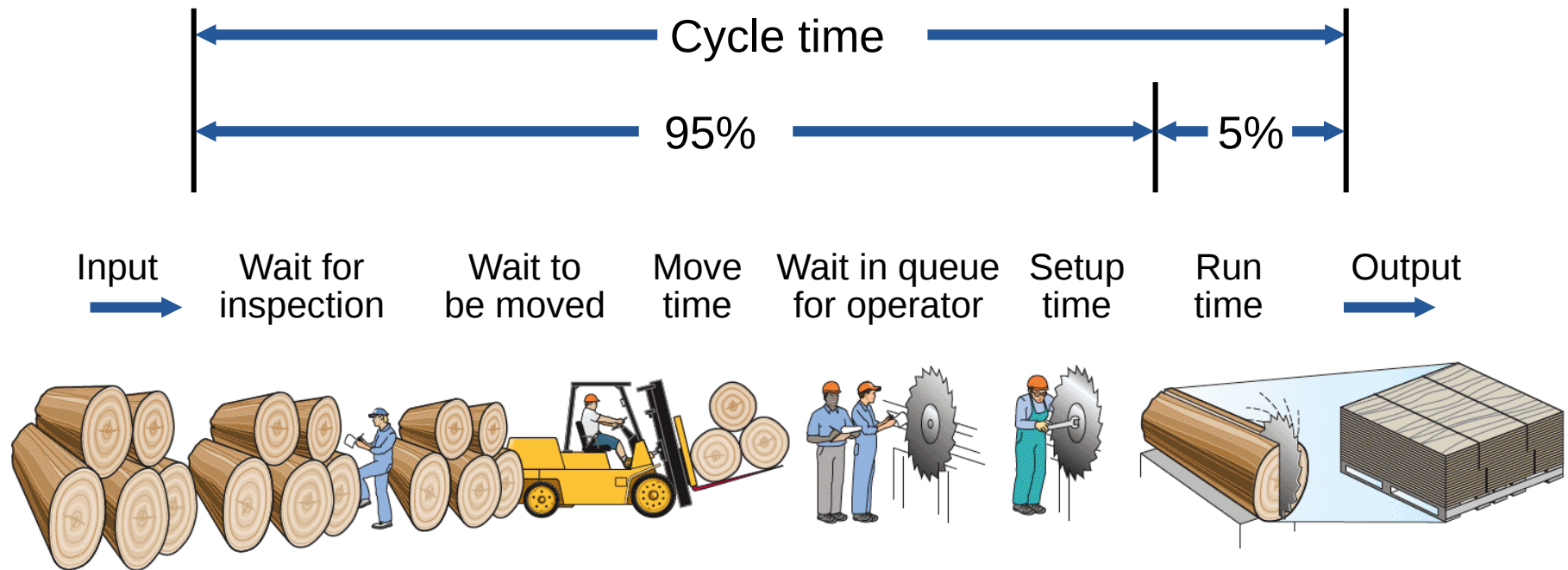


Figure 12.1

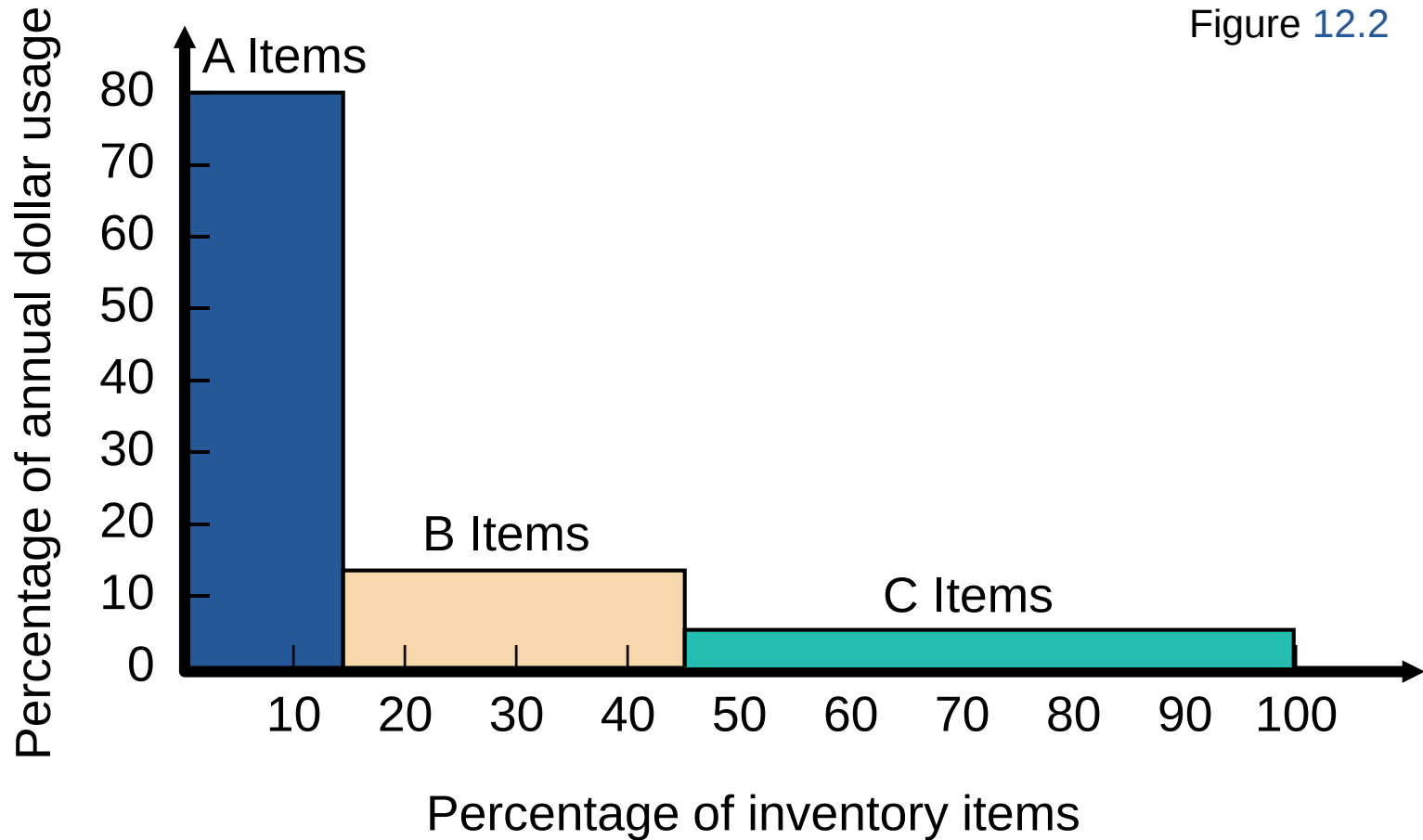
Managing Inventory

- 1) How inventory items can be classified (*ABC analysis*)
- 2) How accurate inventory records can be maintained

ABC Analysis

- ▶ Divides inventory into three classes based on annual dollar volume
 - ▶ Class A - high annual dollar volume
 - ▶ Class B - medium annual dollar volume
 - ▶ Class C - low annual dollar volume
- ▶ Used to establish policies that focus on the few critical parts and not the many trivial ones

ABC Analysis



ABC Analysis

ABC Calculation							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
ITEM STOCK NUMBER	PERCENT OF NUMBER OF ITEMS STOCKED	ANNUAL VOLUME (UNITS)	x UNIT COST	= ANNUAL DOLLAR VOLUME	PERCENT OF ANNUAL DOLLAR VOLUME	CLASS	
#10286	20%	1,000	\$ 90.00	\$ 90,000	38.8%	72%	A
#11526		500	154.00	77,000	33.2%		A
#12760		1,550	17.00	26,350	11.3%	23%	B
#10867	30%	350	42.86	15,001	6.4%		B
#10500		1,000	12.50	12,500	5.4%		B
#12572		600	14.17	8,502	3.7%	5%	C
#14075		2,000	.60	1,200	.5%		C
#01036	50%	100	8.50	850	.4%		C
#01307		1,200	.42	504	.2%		C
#10572		250	.60	150	.1%		C
		<u>8,550</u>		<u>\$232,057</u>	<u>100.0%</u>		

ABC Analysis

- ▶ Other criteria than annual dollar volume may be used
 - ▶ High shortage or holding cost
 - ▶ Anticipated engineering changes
 - ▶ Delivery problems
 - ▶ Quality problems

ABC Analysis

- ▶ Policies employed may include
 1. More emphasis on supplier development for A items
 2. Tighter physical inventory control for A items
 3. More care in forecasting A items

Record Accuracy

- ▶ Accurate records are a critical ingredient in production and inventory systems
 - ▶ *Periodic systems* require regular checks of inventory
 - ▶ *Two-bin system*
 - ▶ *Perpetual inventory* tracks receipts and subtractions on a continuing basis
 - ▶ May be semi-automated



Record Accuracy

- ▶ Incoming and outgoing record keeping must be accurate
- ▶ Stockrooms should be secure
- ▶ Necessary to make precise decisions about ordering, scheduling, and shipping



Cycle Counting

- ▶ Items are counted and records updated on a periodic basis
- ▶ Often used with ABC analysis
- ▶ Has several advantages
 1. Eliminates shutdowns and interruptions
 2. Eliminates annual inventory adjustment
 3. Trained personnel audit inventory accuracy
 4. Allows causes of errors to be identified and corrected
 5. Maintains accurate inventory records

Cycle Counting Example

5,000 items in inventory, 500 A items, 1,750 B items, 2,750 C items

Policy is to count A items every month (20 working days), B items every quarter (60 days), and C items every six months (120 days)

ITEM CLASS	QUANTITY	CYCLE COUNTING POLICY	NUMBER OF ITEMS COUNTED PER DAY
A	500	Each month	$500/20 = 25/\text{day}$
B	1,750	Each quarter	$1,750/60 = 29/\text{day}$
C	2,750	Every 6 months	$2,750/120 = 23/\text{day}$
			77/day

Control of Service Inventories

- ▶ Can be a critical component of profitability
- ▶ Losses may come from shrinkage or pilferage
- ▶ Applicable techniques include
 1. *Good personnel selection, training, and discipline*
 2. *Tight control of incoming shipments*
 3. *Effective control of all goods leaving facility*

Inventory Models

- ▶ **Independent demand** - the demand for item is independent of the demand for any other item in inventory
- ▶ **Dependent demand** - the demand for item is dependent upon the demand for some other item in the inventory

Inventory Models

- ▶ **Holding costs** - the costs of holding or “carrying” inventory over time
- ▶ **Ordering cost** - the costs of placing an order and receiving goods
- ▶ **Setup cost** - cost to prepare a machine or process for manufacturing an order
 - ▶ May be highly correlated with **setup time**

Holding Costs

TABLE 12.1 Determining Inventory Holding Costs

CATEGORY	COST (AND RANGE) AS A PERCENT OF INVENTORY VALUE
Housing costs (building rent or depreciation, operating costs, taxes, insurance)	6% (3 - 10%)
Material handling costs (equipment lease or depreciation, power, operating cost)	3% (1 - 3.5%)
Labor cost (receiving, warehousing, security)	3% (3 - 5%)
Investment costs (borrowing costs, taxes, and insurance on inventory)	11% (6 - 24%)
Pilferage, space, and obsolescence (much higher in industries undergoing rapid change like tablets and smart phones)	3% (2 - 5%)
Overall carrying cost	26%

Holding Costs

TABLE 12.1

Determining Inventory Holding Costs

Holding costs vary considerably depending on the business, location, and interest rates. Generally greater than 15%, some high tech and fashion items have holding costs greater than 40%.

Interest on inventory (including costs, taxes, and insurance on inventory)	11% (6 - 24%)
Pilferage, space, and obsolescence (much higher in industries undergoing rapid change like PCs and cell phones)	3% (2 - 5%)
Overall carrying cost	26%

Inventory Models for Independent Demand

Need to determine when and how much to order

1. Basic economic order quantity (EOQ) model
2. Production order quantity model
3. Quantity discount model

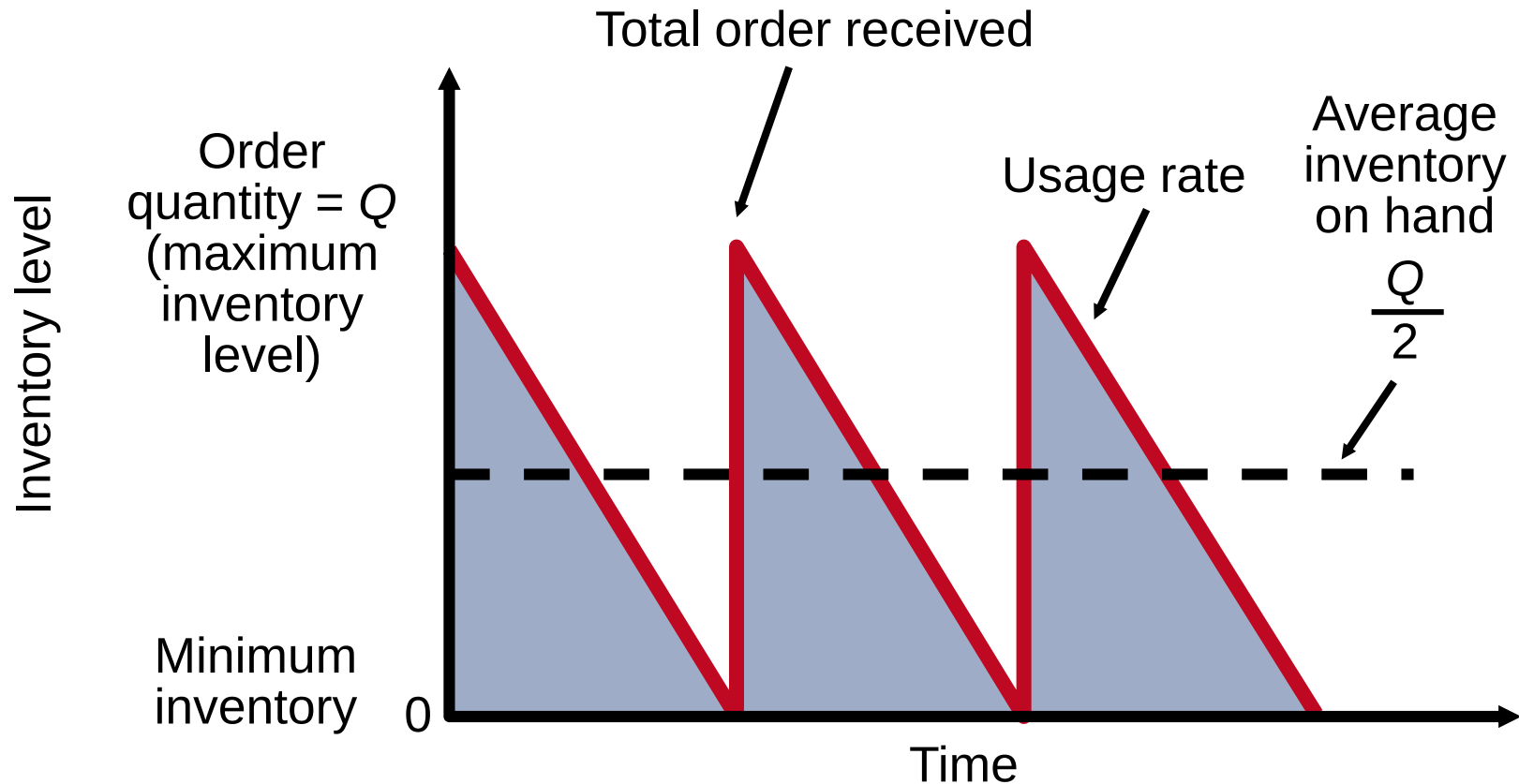
Basic EOQ Model

Important assumptions

1. Demand is known, constant, and independent
2. Lead time is known and constant
3. Receipt of inventory is instantaneous and complete
4. Quantity discounts are not possible
5. Only variable costs are setup (or ordering) and holding
6. Stockouts can be completely avoided

Inventory Usage Over Time

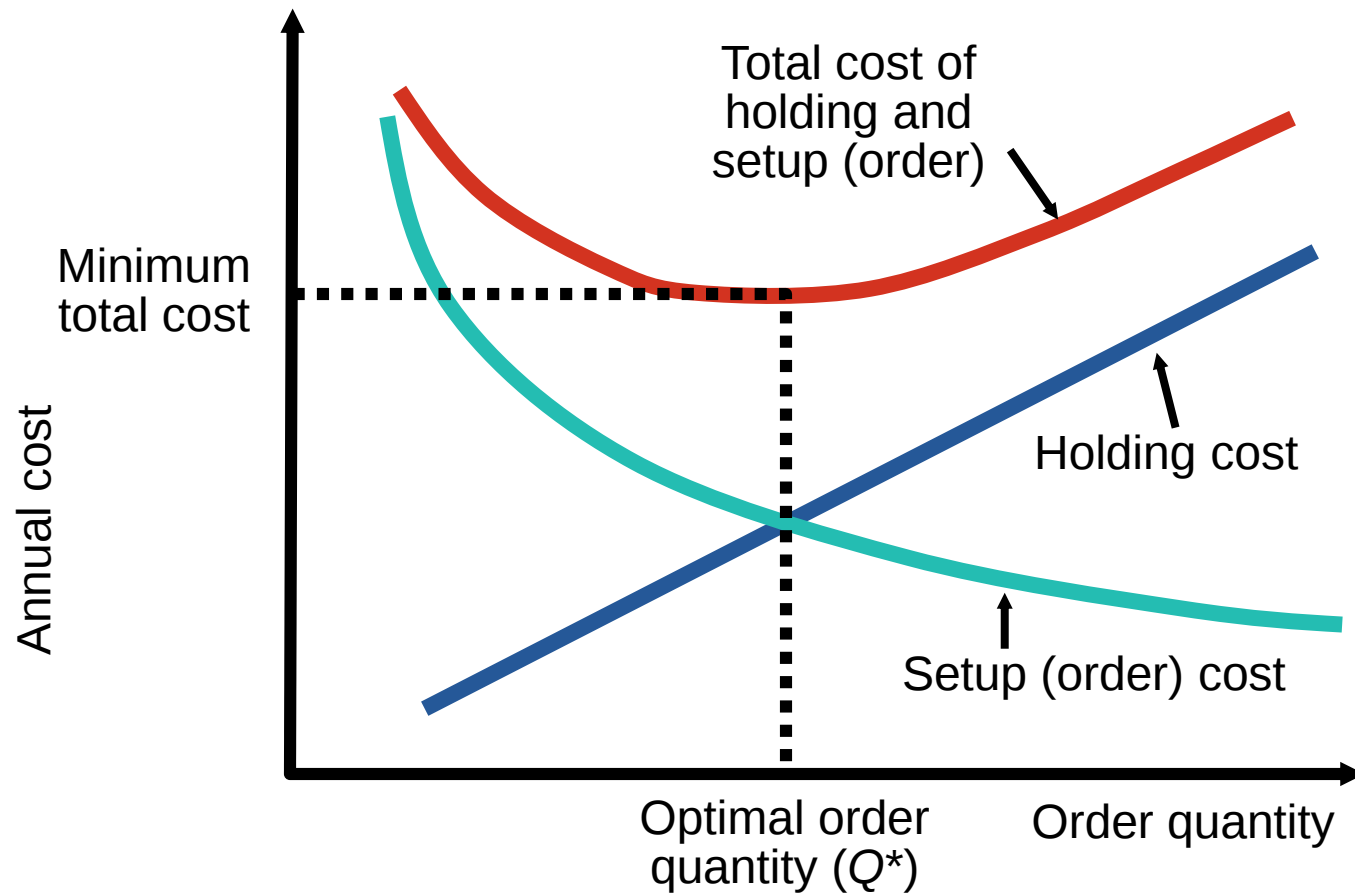
Figure 12.3



Minimizing Costs

Objective is to minimize total costs

Table 12.4(c)



Minimizing Costs

- ▶ By minimizing the sum of setup (or ordering) and holding costs, total costs are minimized
- ▶ Optimal order size Q^* will minimize total cost
- ▶ A reduction in either cost reduces the total cost
- ▶ Optimal order quantity occurs when holding cost and setup cost are equal

Minimizing Costs

Q = Number of units per order

Q^* = Optimal number of units per order (EOQ)

D = Annual demand in units for the inventory item

S = Setup or ordering cost for each order

H = Holding or carrying cost per unit per year

Annual setup cost = (Number of orders placed per year)
x (Setup or order cost per order)

$$= \left(\frac{\text{Annual demand}}{\text{Number of units in each order}} \right) \left(\text{Setup or order cost per order} \right)$$

$$= \frac{D}{Q} S$$

Minimizing Cost

$$\text{Annual setup cost} = \frac{D}{Q} S$$

Q = Number of pieces per order

Q^* = Optimal number of pieces per order (EOQ)

D = Annual demand in units for the inventory item

S = Setup or ordering cost for each order

H = Holding or carrying cost per unit per year

Annual setup cost = (Number of orders placed per year)
x (Setup or order cost per order)

$$= \left(\frac{\text{Annual demand}}{\text{Number of units in each order}} \right) \left(\text{Setup or order cost per order} \right)$$

$$= \frac{D}{Q} S$$

Minimizing Cost

$$\text{Annual setup cost} = \frac{D}{Q} S$$

$$\text{Annual holding cost} = \frac{Q}{2} H$$

Q = Number of pieces per order

Q^* = Optimal number of pieces per order (EOQ)

D = Annual demand in units for the inventory item

S = Setup or ordering cost for each order

H = Holding or carrying cost per unit per year

Annual holding cost = (Average inventory level)
x (Holding cost per unit per year)

$$= \left(\frac{\text{Order quantity}}{2} \right) (\text{Holding cost per unit per year})$$

$$= \frac{Q}{2} H$$

Minimizing Cost

$$\text{Annual setup cost} = \frac{D}{Q} S$$

$$\text{Annual holding cost} = \frac{Q}{2} H$$

Q = Number of pieces per order

Q^* = Optimal number of pieces per order (EOQ)

D = Annual demand in units for the inventory item

S = Setup or ordering cost for each order

H = Holding or carrying cost per unit per year

Optimal order quantity is found when annual setup cost equals annual holding cost

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

Solving for Q^*

$$2DS = Q^2 H$$

$$Q^2 = \frac{2DS}{H}$$

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

An EOQ Example

Determine **optimal number of needles to order**

$D = 1,000$ units

$S = \$10$ per order

$H = \$0.50$ per unit per year

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

$$Q^* = \sqrt{\frac{2(1,000)(10)}{0.50}} = \sqrt{40,000} = 200 \text{ units}$$

An EOQ Example

Determine **expected number of orders**

$D = 1,000$ units

$Q^* = 200$ units

$S = \$10$ per order

$H = \$0.50$ per unit per year

$$\begin{array}{l} \text{Expected} \\ \text{number of} \\ \text{orders} \end{array} = N = \frac{\text{Demand}}{\text{Order quantity}} = \frac{D}{Q^*}$$

$$N = \frac{1,000}{200} = 5 \text{ orders per year}$$

An EOQ Example

Determine **optimal time between orders**

$D = 1,000$ units

$Q^* = 200$ units

$S = \$10$ per order

$N = 5$ orders/year

$H = \$0.50$ per unit per year

$$\begin{array}{l} \text{Expected} \\ \text{time between} \\ \text{orders} \end{array} = T = \frac{\text{Number of working days per year}}{\text{Expected number of orders}}$$

$$T = \frac{250}{5} = 50 \text{ days between orders}$$

An EOQ Example

Determine the **total annual cost**

$D = 1,000$ units

$Q^* = 200$ units

$S = \$10$ per order

$N = 5$ orders/year

$H = \$0.50$ per unit per year

$T = 50$ days

Total annual cost = Setup cost + Holding cost

$$\begin{aligned} TC &= \frac{D}{Q} S + \frac{Q}{2} H \\ &= \frac{1,000}{200} (\$10) + \frac{200}{2} (\$0.50) \\ &= (5)(\$10) + (100)(\$0.50) \\ &= \$50 + \$50 = \$100 \end{aligned}$$

The EOQ Model

When including actual cost of material P

Total annual cost = Setup cost + Holding cost + Product cost

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

Robust Model

- ▶ The EOQ model is **robust**
- ▶ It works even if all parameters and assumptions are not met
- ▶ The total cost curve is relatively flat in the area of the EOQ

An EOQ Example

Determine optimal number of needles to order

$$D = \del{1,000 \text{ units}} 1,500 \text{ units} \quad Q^*_{1,000} = 200 \text{ units}$$

$$S = \$10 \text{ per order} \quad T = 50 \text{ days}$$

$$H = \$0.50 \text{ per unit per year} \quad Q^*_{1,500} = 244.9 \text{ units}$$

$$N = 5 \text{ orders/year}$$

Ordering old Q^*

$$\begin{aligned} TC &= \frac{D}{Q} S + \frac{Q}{2} H \\ &= \frac{1,500}{200} (\$10) + \frac{200}{2} (\$0.50) \\ &= \$75 + \$50 = \$125 \end{aligned}$$

Ordering new Q^*

$$\begin{aligned} &= \frac{1,500}{244.9} (\$10) + \frac{244.9}{2} (\$0.50) \\ &= 6.125 (\$10) + 122.45 (\$0.50) \\ &= \$61.25 + \$61.22 = \$122.47 \end{aligned}$$

An EOQ Example

Determine optimal number of

~~$D = 1,000$ units~~ 1,500 units

$S = \$10$ per order

$H = \$0.50$ per unit per year

$N = 5$ orders/year

Only 2% less than
the total cost of
\$125 when the
order quantity was
200

Ordering old Q^*

Or

$$\begin{aligned} TC &= \frac{D}{Q} S + \frac{Q}{2} H \\ &= \frac{1,500}{200} (\$10) + \frac{200}{2} (\$0.50) \\ &= \$75 + \$50 = \$125 \end{aligned}$$

$$\begin{aligned} &= \frac{1,500}{244.9} (\$10) + \frac{244.9}{2} (\$0.50) \\ &= 6.125 (\$10) + 122.45 (\$0.50) \\ &= \$61.25 + \$61.22 = \$122.47 \end{aligned}$$

Reorder Points

- ▶ EOQ answers the “how much” question
- ▶ The reorder point (ROP) tells “when” to order
- ▶ Lead time (L) is the time between placing and receiving an order

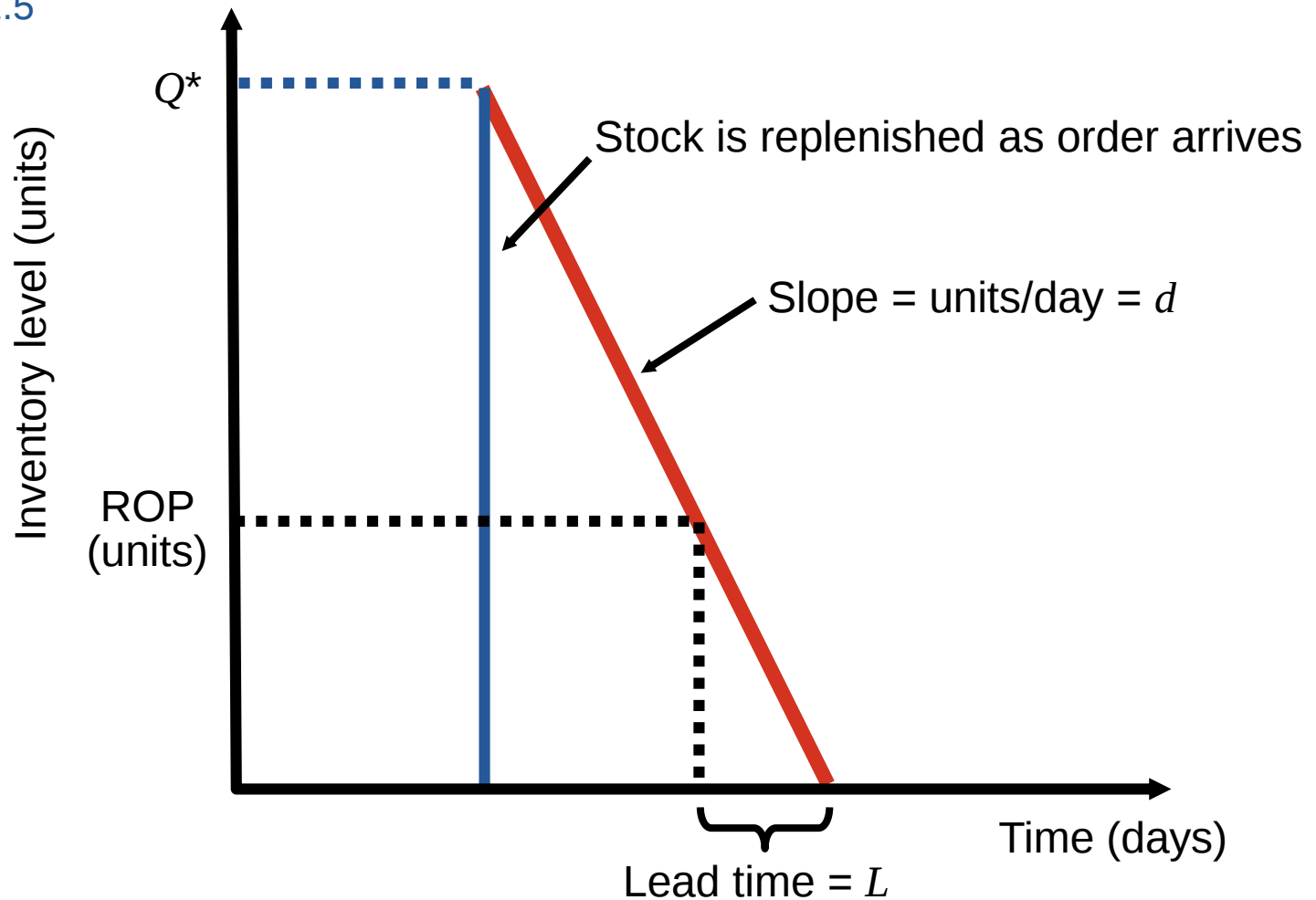
$$\text{ROP} = \left(\begin{array}{c} \text{Demand} \\ \text{per day} \end{array} \right) \left(\begin{array}{c} \text{Lead time for a new} \\ \text{order in days} \end{array} \right)$$

$$\text{ROP} = d \times L$$

$$d = \frac{D}{\text{Number of working days in a year}}$$

Reorder Point Curve

Figure 12.5



Reorder Point Example

Demand = 8,000 iPhones per year

250 working day year

Lead time for orders is 3 working days, may take 4

$$d = \frac{D}{\text{Number of working days in a year}}$$

$$= 8,000/250 = 32 \text{ units}$$

$$\text{ROP} = d \times L$$

$$= 32 \text{ units per day} \times 3 \text{ days} = 96 \text{ units}$$

$$= 32 \text{ units per day} \times 4 \text{ days} = 128 \text{ units}$$



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