LECTURE 9
CAPACITY& REVENUE MANAGEMENT

Instructor: Lu Wang

College of Business

Shanghai University of Finance and Economics

CAPACITY MANAGEMENT IN OPERATIONS

- **Capacity – the ability to hold, receive, store, or accommodate**
- **In business, viewed as the amount of output that a system is capable of achieving over a specific period of time**
  - In a service setting, this might be the number of customers that can be handled between noon and 1:00 p.m. In manufacturing, this might be the number of automobiles that can be produced in a single shift.
- **Capacity management needs to consider both inputs and outputs**

CAPACITY PLANNING TIME DURATIONS

Long range

- Greater than one year

Intermediate range

- Monthly or quarterly plans covering the next 6 to 18 months

Short range

- Less than one month

STRATEGIC CAPACITY PLANNING

Determining the overall level of capacity-intensive resources that best supports the company's long-range competitive strategy

- Facilities
- Major equipment
- Labor force size

CAPACITY PLANNING CONCEPTS

- **Capacity utilization rate – a measure of how close the firm is to its best possible operating level**

$$Capacity\ utilization\ rate = \frac{Capacity\ used}{Best\ operating\ level}$$

- **Economies of scale – the idea that as a plant gets larger and volume increases, the average cost per unit tends to drop**
- **Diseconomies of scale – at some point, the plant becomes too large and average cost per unit begins to increase**

CAPACITY PLANNING CONCEPTS

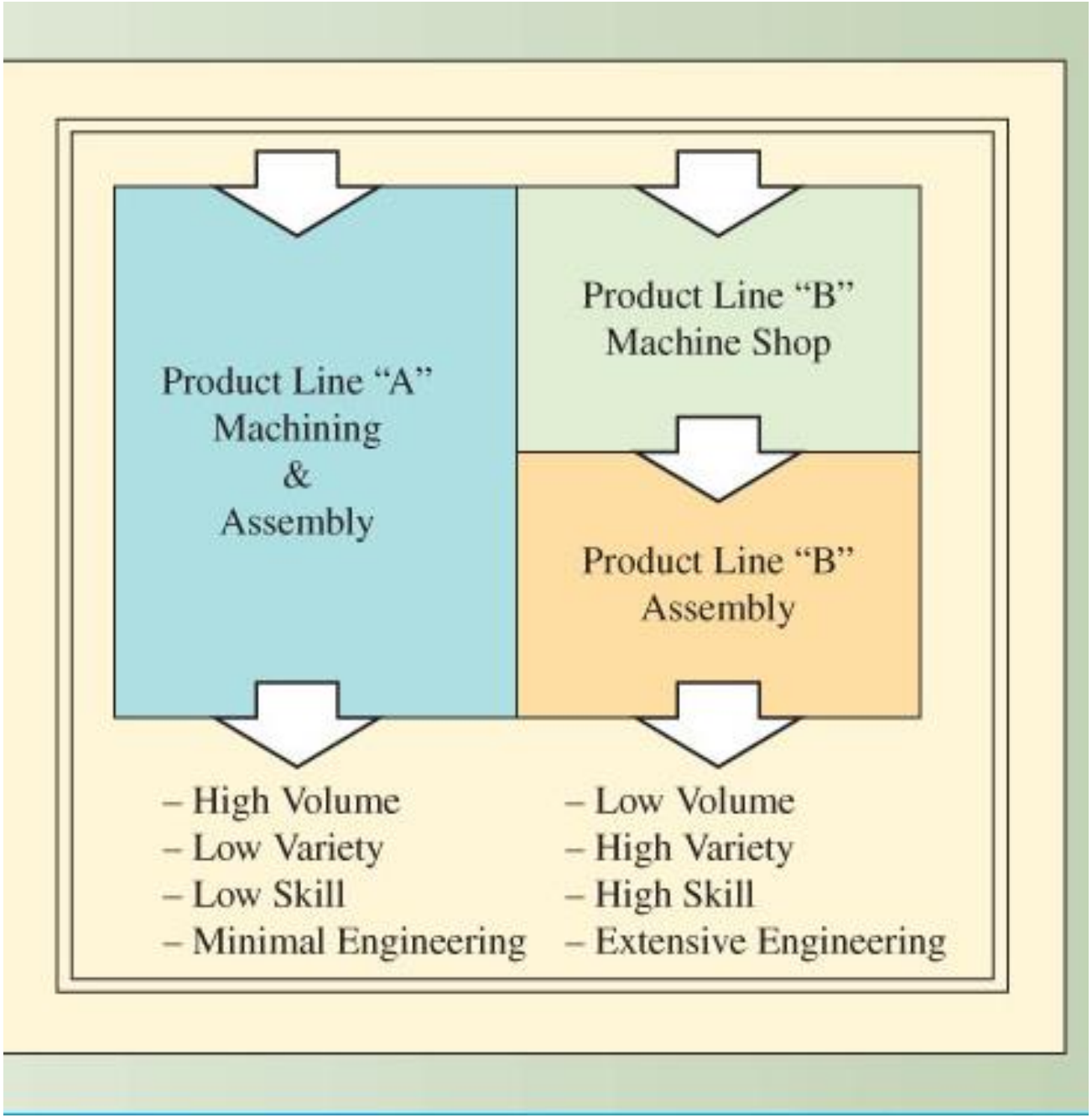
Capacity focus – the idea that a production facility works best when it is concentrated on a limited set of production objectives

- Focused factory or plant within a plant (PWP) concept

Capacity flexibility – the ability to rapidly increase or decrease production levels or the ability to shift rapidly from one product or service to another

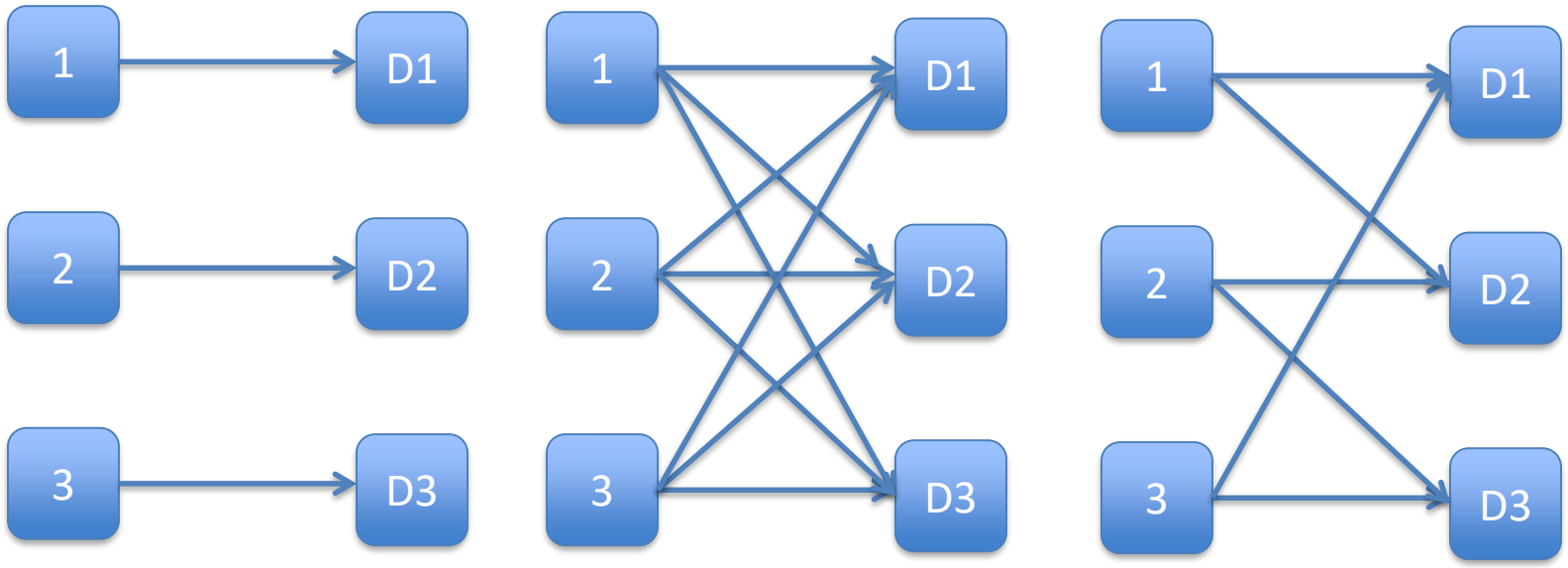
- Comes from the plant, processes, and workers or from strategies that use the capacity of other organizations

PWP


Product Line "A"
Machining
&
Assembly
Product Line "B"
Machine Shop
Product Line "B"
Assembly
– High Volume
– Low Variety
– Low Skill
– Minimal Engineering
– Low Volume
– High Variety
– High Skill
– Extensive Engineering

CAPACITY FLEXIBILITY

Capacity flexibility means having the ability to rapidly increase or decrease production levels, or to shift production capacity quickly from one product or service to another.



Dedicated System

Total Flexibility

Long Chain

CAPACITY FLEXIBILITY

Flexible Plants	• Ability to quickly adapt to change • Zero-changeover time
Flexible Processes	• Flexible manufacturing systems • Simple, easily set up equipment
Flexible Workers	• Ability to switch from one kind of task to another quickly • Multiple skills (cross training)

CONSIDERATIONS IN CHANGING CAPACITY

Maintaining System Balance

- Similar capacities desired at each operation
- Manage bottleneck operations

Frequency of Capacity Additions

- Cost of upgrading too frequently
- Cost of upgrading too infrequently

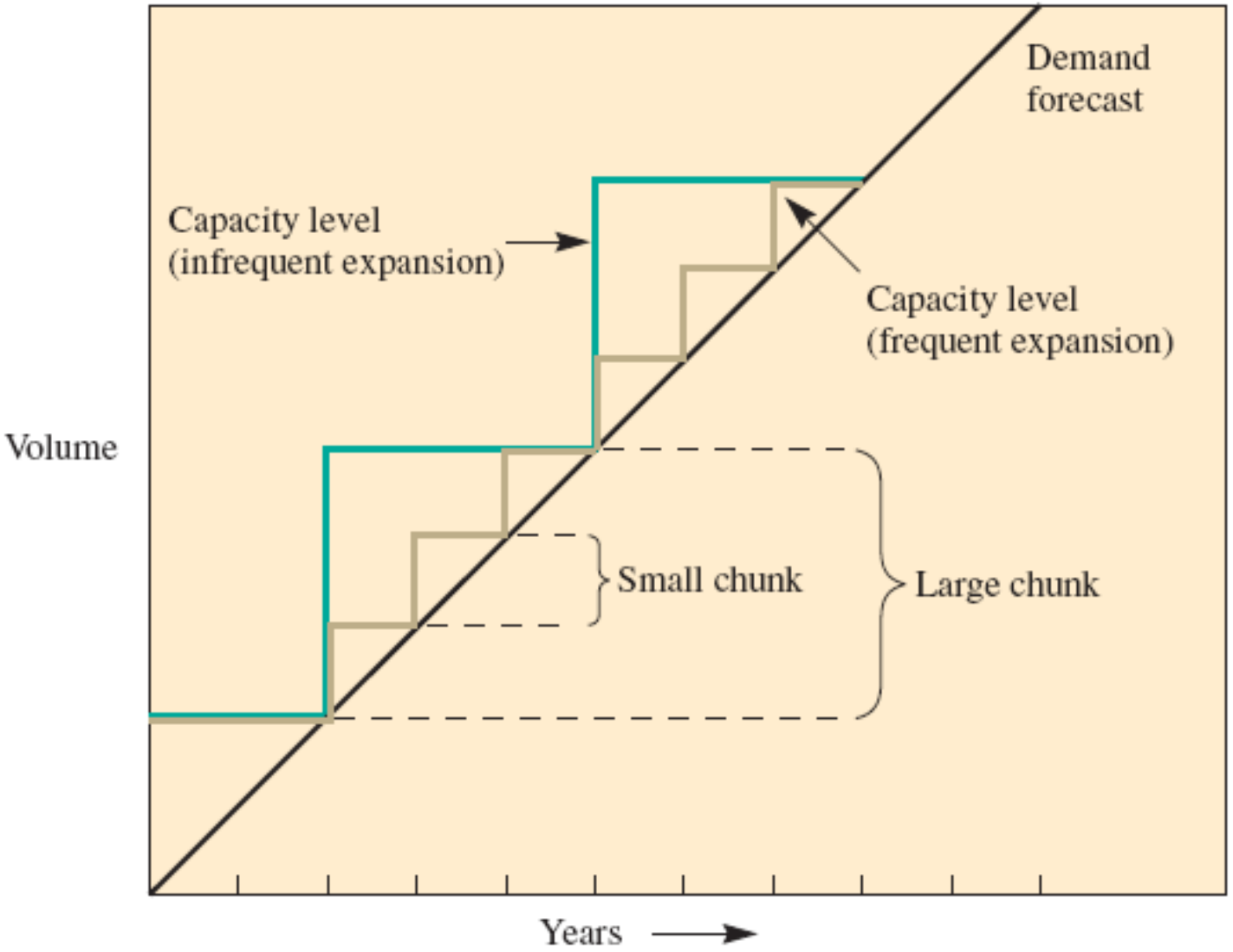
External Sources of Capacity

- Outsourcing
- Sharing capacity

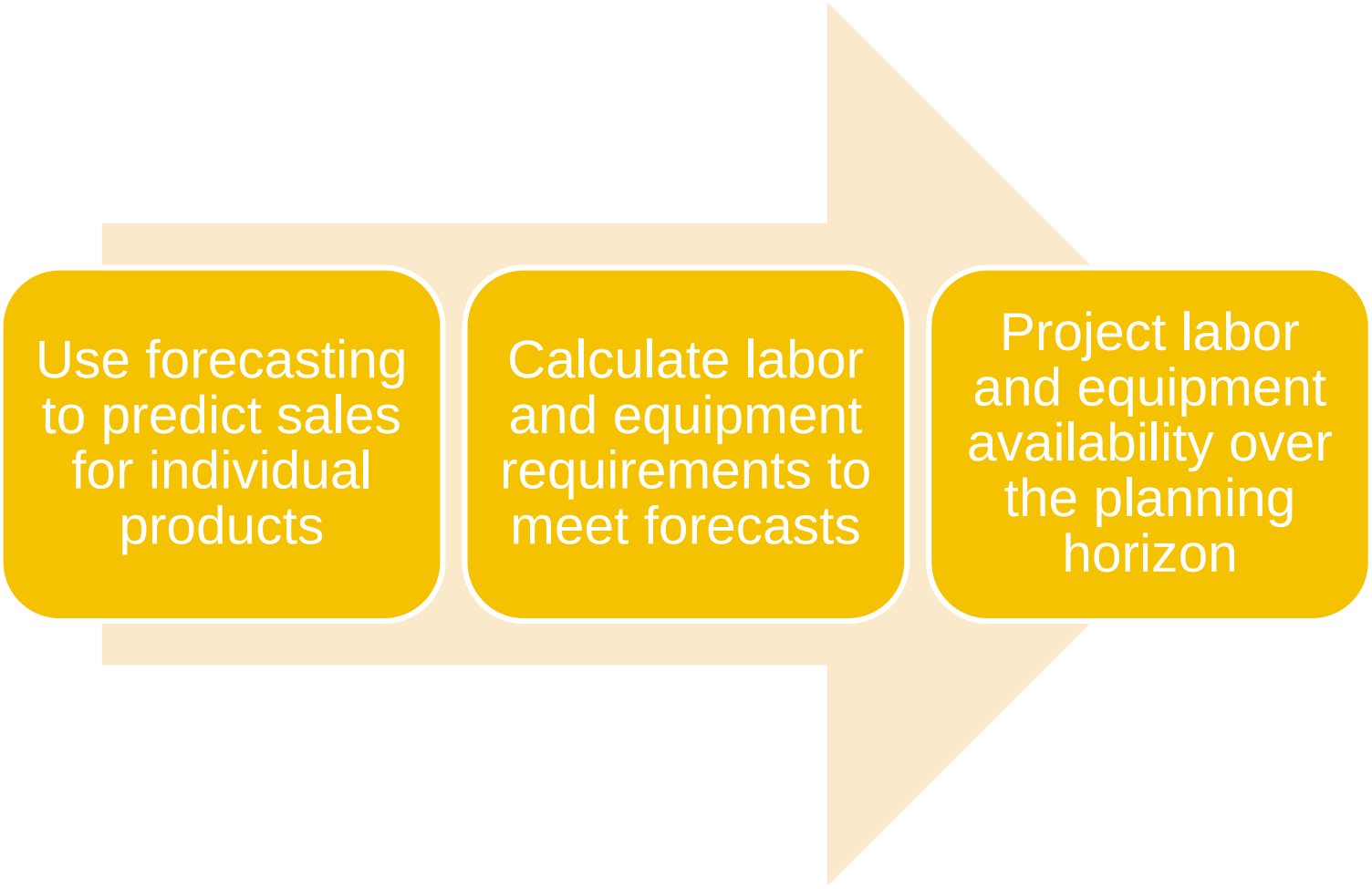
Decreasing Capacity

- Temporary reductions
- Permanent reductions

FREQUENT VERSUS INFREQUENT CAPACITY EXPANSIONS



DETERMINING CAPACITY REQUIREMENTS



EXAMPLE 5.1—DETERMINING CAPACITY REQUIREMENTS

- **Stewart Company produces two flavors of salad dressing.**
  - Paul's and Newman's
- **Each is available in bottles and single-serving bags.**
- **3 bottling machines and 5 bagging machines**
- **Each bottling machine needs 2 operators while each bagging machine needs 3 operators**
- **Each bottling machine packages 150,000 bottles per year while each bagging machine packages 250,000 bags per year**
- **What are the capacity and labor requirements for the next five years?**

DETERMINING CAPACITY REQUIREMENTS

Step 1: Use forecasting to predict sales for individual products		Year				
		1	2	3	4	5
Paul's	Bottles (000s)	60	100	150	200	250
	Plastic bags (000s)	100	200	300	400	500
Newman's	Bottles (000s)	75	85	95	97	98
	Plastic bags (000s)	200	400	600	650	680

DETERMINING CAPACITY REQUIREMENTS

Step 2: Calculate equipment and labor requirements

	Year				
	1	2	3	4	5
Bottles (000s)	135	185	245	297	348
Plastic bags (000s)	300	600	900	1050	1180

Bottling Operation

- Capacity – 450,000
- Operators – 6
- Year 1
  - Capacity utilization $= \frac{135}{450} = 0.3$
  - Machine requirement $= 0.3 \times 3 = 0.9$
  - $Labor\ requirement = 0.9 \times 2 = 1.8$

Bagging Operation

- Capacity – 1,250,000
- Operators - 15
- Year 1
  - Capacity utilization $= \frac{300}{1{,}250} = 0.24$
  - Machine requirement $= 0.24 \times 5 = 1.2$
  - $Labor\ requirement = 1.2 \times 3 = 3.6$

DETERMINING CAPACITY REQUIREMENTS

Step 3: Project equipment and labor availabilities		Year				
		1	2	3	4	5
Plastic Bag Operation	Percentage capacity utilized	24%	48%	72%	84%	94%
	Machine requirement	1.2	2.4	3.6	4.2	4.7
	Labor requirement	3.6	7.2	10.8	12.6	14.1
Bottle Operation	Percentage capacity utilized	30%	41%	54%	66%	77%
	Machine requirement	0.9	1.23	1.62	1.98	2.31
	Labor requirement	1.8	2.46	3.24	3.96	4.62

DECISION TREES FOR CAPACITY ANALYSIS

A decision tree is a schematic model of the sequence of steps in a problem – including the conditions and consequences of each step.

Decision trees help analysts understand the problem and assist in identifying the best solution in the presence of uncertainty.

Decision tree components include the following:

- Decision nodes – represented with squares
- Chance nodes – represented with circles
- Paths – links between nodes

EXAMPLE 5.2: DECISION TREES

The owner of Hackers Computer Store is evaluating three options – expand at current site, expand to a new site, do nothing for the next 5 years.

The decision process includes the following assumptions and conditions.

- Strong growth has a 55% probability
- New site cost is $210,000
    - Payoffs: strong growth = $195,000; weak growth = $115,000
- Expanding current site cost is $87,000 (in either year 1 or 2)
    - Payoffs: strong growth = $170,000; weak growth = $100,000
- Do nothing
    - Payoffs: strong growth = $130,000; weak growth = $85,000

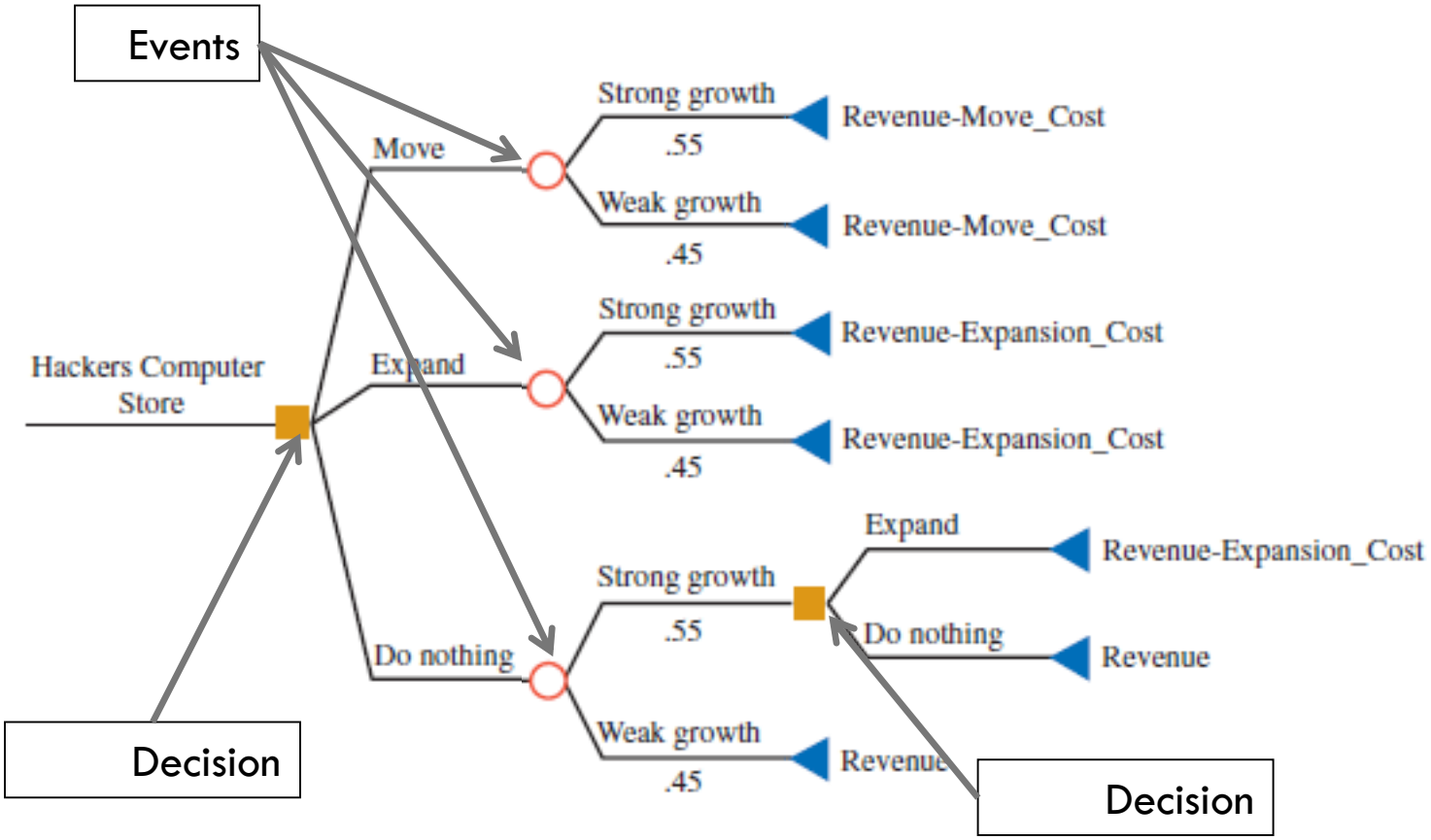
EXAMPLE 5.2: DECISION TREES

Calculate the value of each alternative

Alternative/outcome	Revenue	Cost	Value
Move/strong growth	195,000*5	210,000	765,000
Move/weak growth	115,000*5	210,000	365,000
Expand/strong growth	170,000*5	87,000	763,000
Expand/weak growth	100,000*5	87,000	413,000
Do nothing now/strong growth, expand next year	130,000*1+170,000*4	87,000	723,000
Do nothing now/ strong growth, do not expand next year	130,000*5	0	650,000
Do nothing now/ weak growth	85,000*5	0	425,000

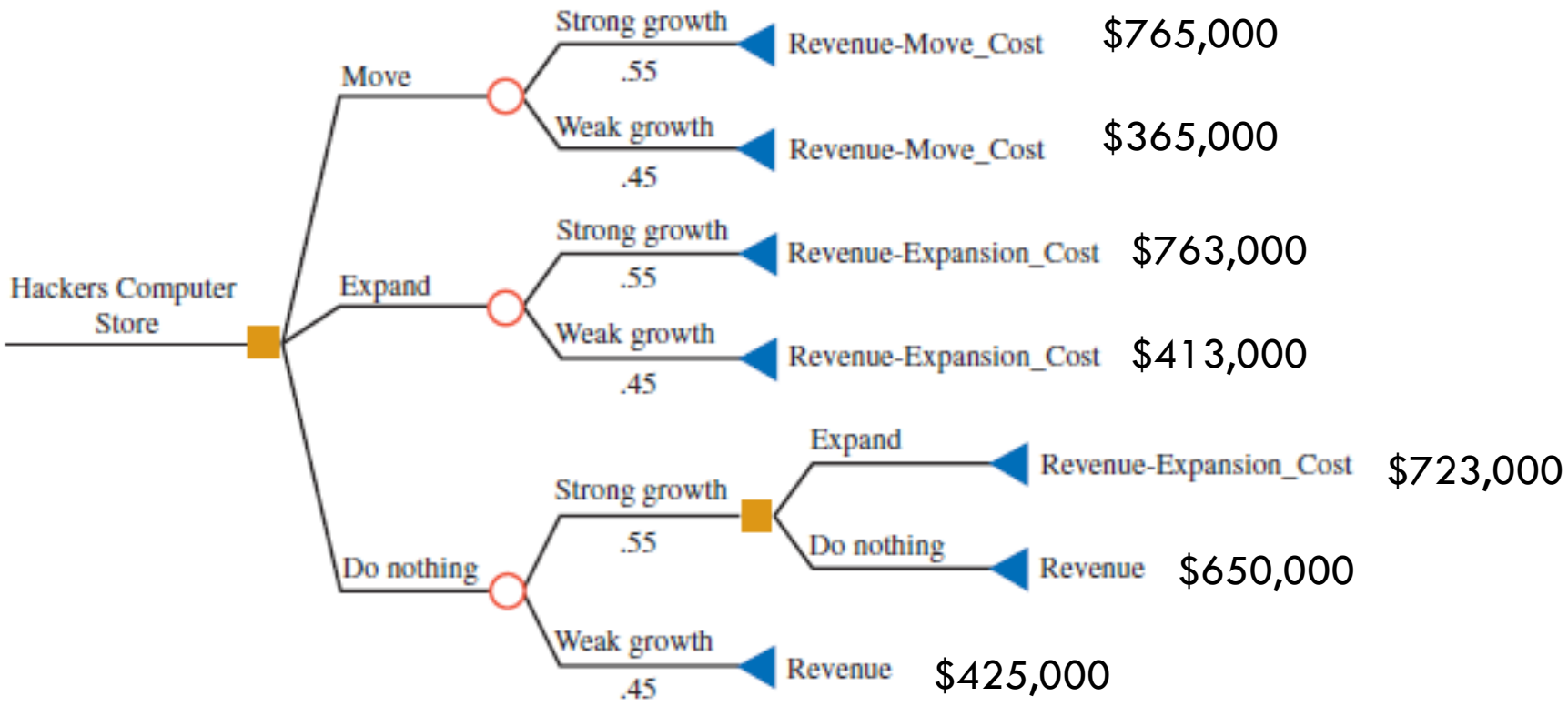
EXAMPLE 5.2: DECISION TREES

Diagram the problem chronologically



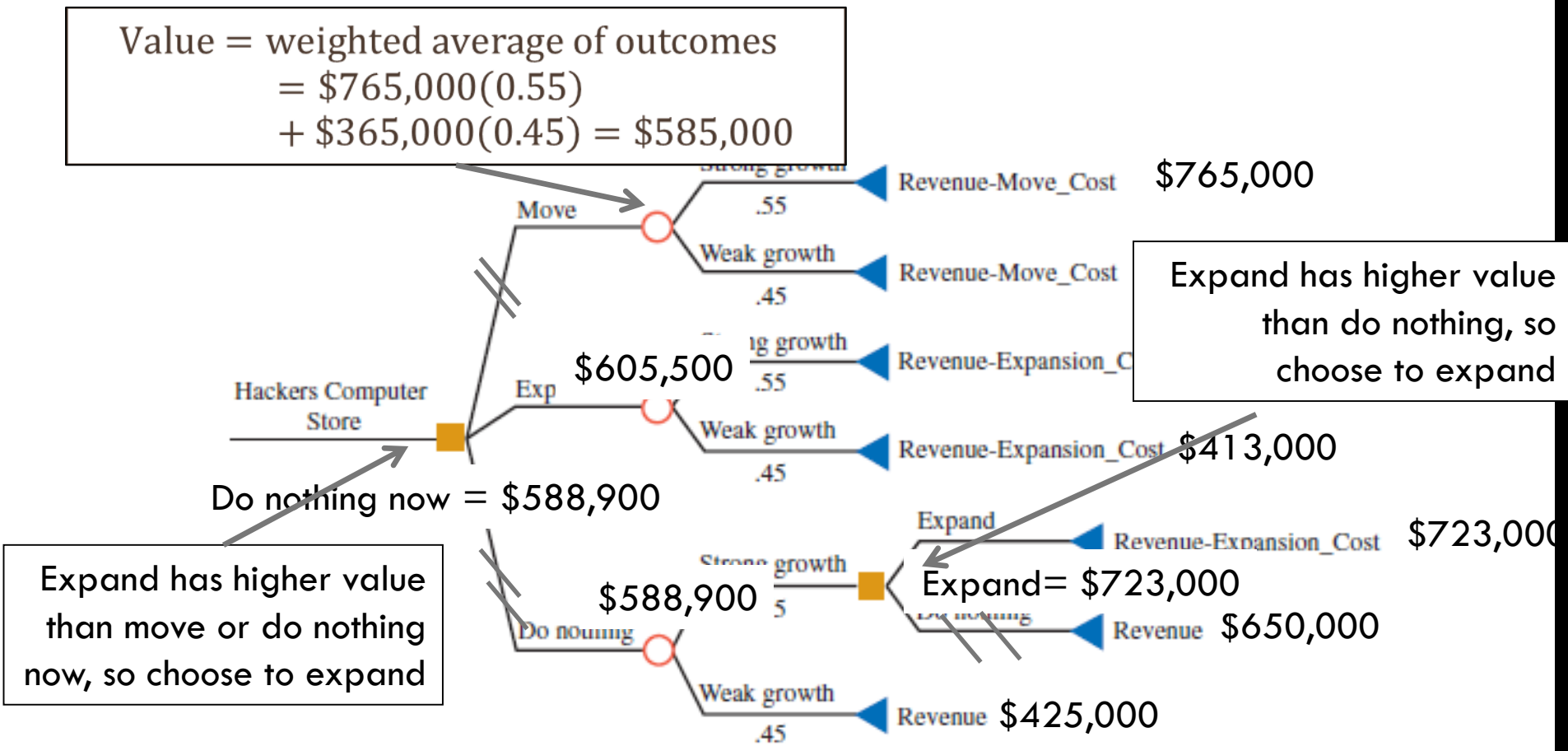
EXAMPLE 5.2: DECISION TREES

Calculate value of each branch



EXAMPLE 5.2

Work backwards to calculate the value of each decision/event



PLANNING SERVICE CAPACITY

Manufacturing Capacity

- Goods can be stored for later use.
- Goods can be shipped to other locations.
- Volatility of demand is relatively low.

Service Capacity

- Capacity must be available when service is needed – cannot be stored.
- Service must be available at customer demand point.
- Much higher volatility is typical.

CAPACITY UTILIZATION AND SERVICE QUALITY

The relationship between service capacity utilization and service quality is critical.

- Utilization is measured by the portion of time servers are busy.

Optimal levels of utilization are context specific.

- Low rates are appropriate when the degree of uncertainty (in demand) is high and/or the stakes are high (e.g., emergency rooms, fire departments).
- Higher rates are possible for predictable services or those without extensive customer contact (e.g., commuter trains, postal sorting).

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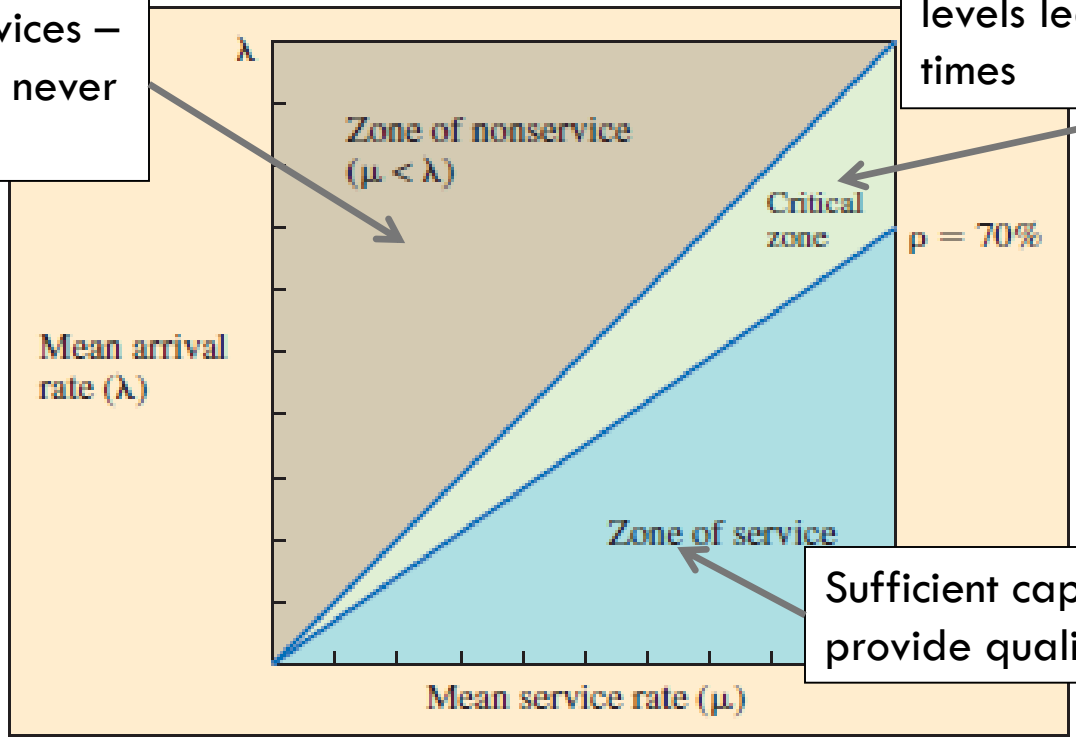
SERVICE QUALITY

Rate of service utilization and service quality are directly linked.

Arrivals exceed services – many customers are never served

Service quality declines – disruptions or high arrival levels lead to long wait times



Sufficient capacity to provide quality service

REVENUE MANAGEMENT

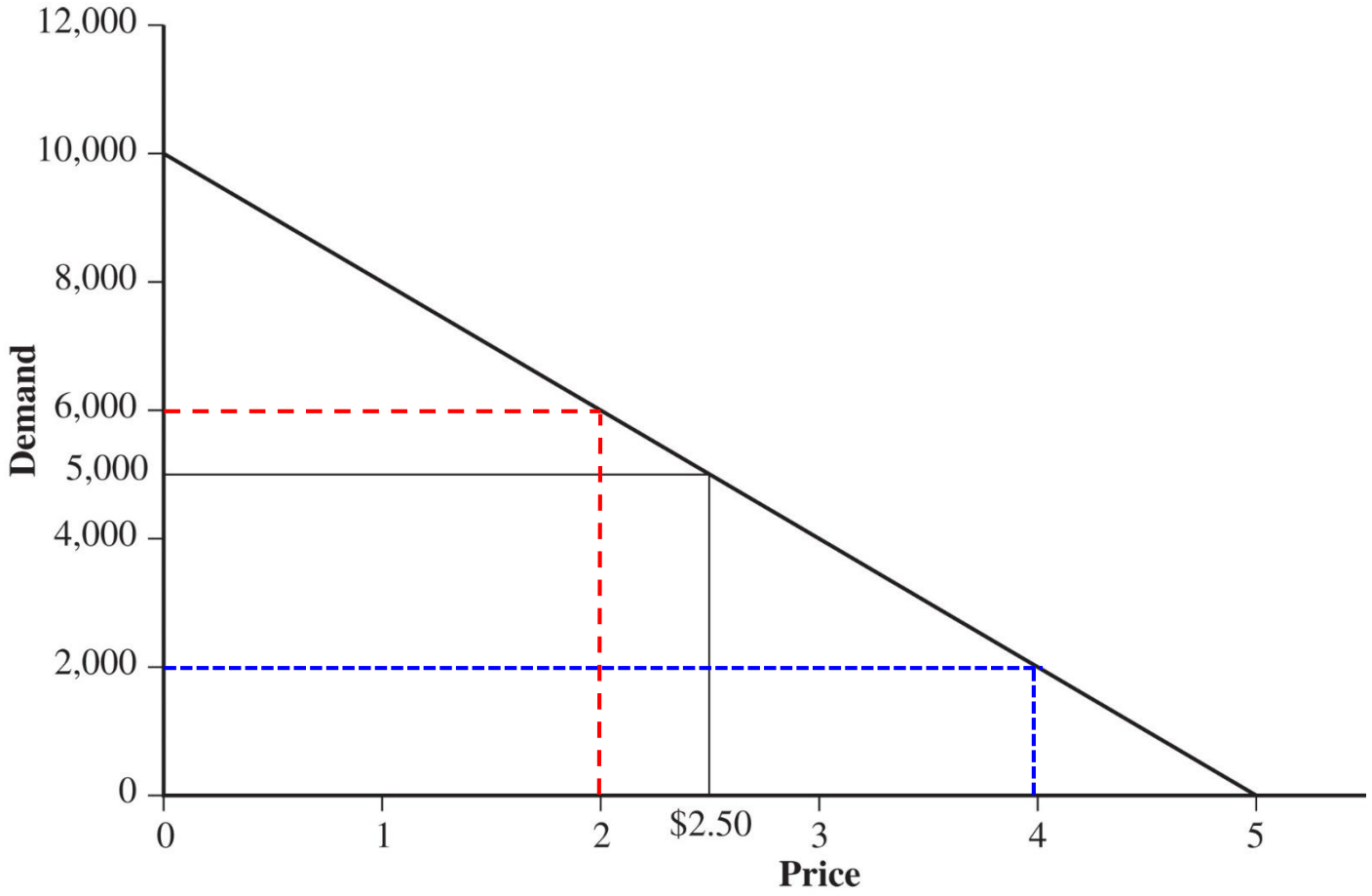
THE ROLE OF PRICING AND REVENUE MANAGEMENT

- Revenue management is the use of pricing to increase the profit generated from a limited supply of supply chain assets
- Supply assets often exist in two forms – capacity and inventory
- Revenue management may also be defined as the use of differential pricing based on customer segment, time of use, and product or capacity availability to increase supply chain profits

AN EXAMPLE

- Consider a trucking company that has a fleet with 6 trucks and a total shipping capacity of 6,000 cubic feet, to use for transport between Shanghai and Beijing
- Market research indicates the demand for trucking capacity is: $d = 10{,}000 - 2{,}000p$

AN EXAMPLE (CONT'D)

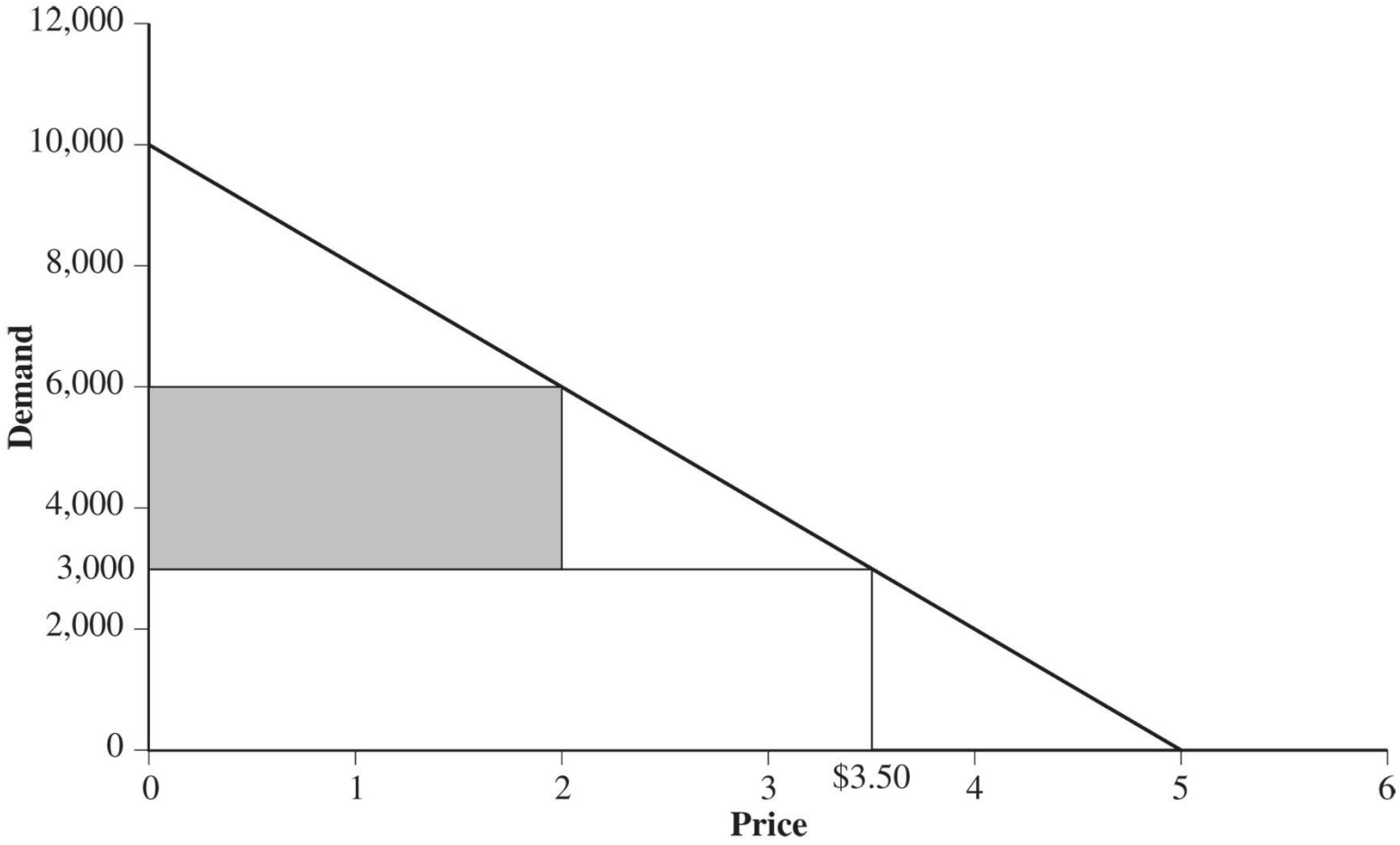


AN EXAMPLE (CONT'D)

- Set price at 3.5/cubic feet, it can sell 3,000
- Set price at 2/cubic feet, it can sell 6,000
- What if the trucking company could set price at 3.5/cubic feet to sell to high-price customers and sell the remaining 3,000 to low-price customers at 2/cubic feet?
- Total revenue:

$$3.5 * 3000 + 2 * 3000 = 165{,}000$$

AN EXAMPLE (CONT'D)



THE ROLE OF PRICING AND REVENUE MANAGEMENT

Revenue management has a significant impact on supply chain profitability when one or more of the following three conditions exist

- The value of the product varies in different market segments
- The product is highly perishable or product waste occurs
- Demand has seasonal and other peaks

PRICING TO MULTIPLE SEGMENTS

Demand curve for segment $i = d_i = A_i - B_i p_i$

$$\text{Max} \sum_{i=1}^{k} (p_i - c)(A_i - B_i p_i)$$

Subject to $A_i - B_i p_i \geq 0$ for $i = 1, \ldots, k$

Optimal price $= p_i = \frac{A_i}{2B_i} + \frac{c}{2}$

PRICING TO MULTIPLE SEGMENTS: ANOTHER EXAMPLE

$$\text{Customers unwilling to commit } d_1 = 5{,}000 - 20p_1$$

$$\text{Customer willing to commit } d_2 = 5{,}000 - 40p_2$$

$$c = \$10$$

$$p_1 = \frac{5{,}000}{2 \times 20} + \frac{10}{2} = 125 + 5 = \$130$$

$$p_2 = \frac{5{,}000}{2 \times 40} + \frac{10}{2} = 62.5 + 5 = \$67.5$$

$$d_1 = 5{,}000 - 20 \times 130 = 2{,}400 \text{ and } d_2 = 5{,}000 - 40 \times 67.5 = 2{,}300$$

$$\text{Total profit} = 130 \times 2{,}400 + 67.5 \times 2{,}300 - 10 \times 4{,}700 = \$420{,}250$$

ANOTHER EXAMPLE (CONT'D)

Same price to both segments

$$(p-10)(5{,}000-20p)+(p-10)(5{,}000-40p)$$
$$=(p-10)(10{,}000-60p)$$

$$\text{Optimal price } p=\frac{10{,}000}{2\times 60}+\frac{10}{2}=\$88.33$$

$$d_1=5{,}000-20\times 88.33=3{,}233.40$$
$$d_2=5{,}000-40\times 88.33=1{,}466.80$$

$$\text{Total profit}=(88.33-10)\times(3{,}233.40+1{,}466.80)=\$368{,}166.67$$

REVENUE MANAGEMENT FOR MULTIPLE CUSTOMER SEGMENTS

Differential pricing increases total profits for a firm

Two fundamental issues must be handled in practice

- How can the firm differentiate between the two segments and structure its pricing to make one segment pay more than the other?
- How can the firm control demand such that the lower-paying segment does not utilize the entire availability of the asset?

DIFFERENTIATE DEMAND SEGMENTS

Create different versions of a product targeted at different segments

Tactics for multiple customer segments

- Forecast at the segment level
- Use different prices for different segments
- Price based on the value assigned by each segment

REVENUE MANAGEMENT CHALLENGE: STRATEGIC CUSTOMER BEHAVIORS

- What is strategic consumer behavior?
- Why is it a problem for RM?

ELIMINATE THE NEED FOR MARKDOWN

- **Better forecasting**
- **Better inventory control**
- **Better supply chain management**

REDUCE STRATEGIC WAITING

Why don’t all consumers wait for markdown?

Value Depreciation

Risk of stock-out

BROADWAY TICKETS

Purchase in Advance	Same Day Purchase
Full price: US$90 or more	25-50% discount

READING TEST

In four pages of an English novel (2000 words), how many words would you expect to find that have the following form?

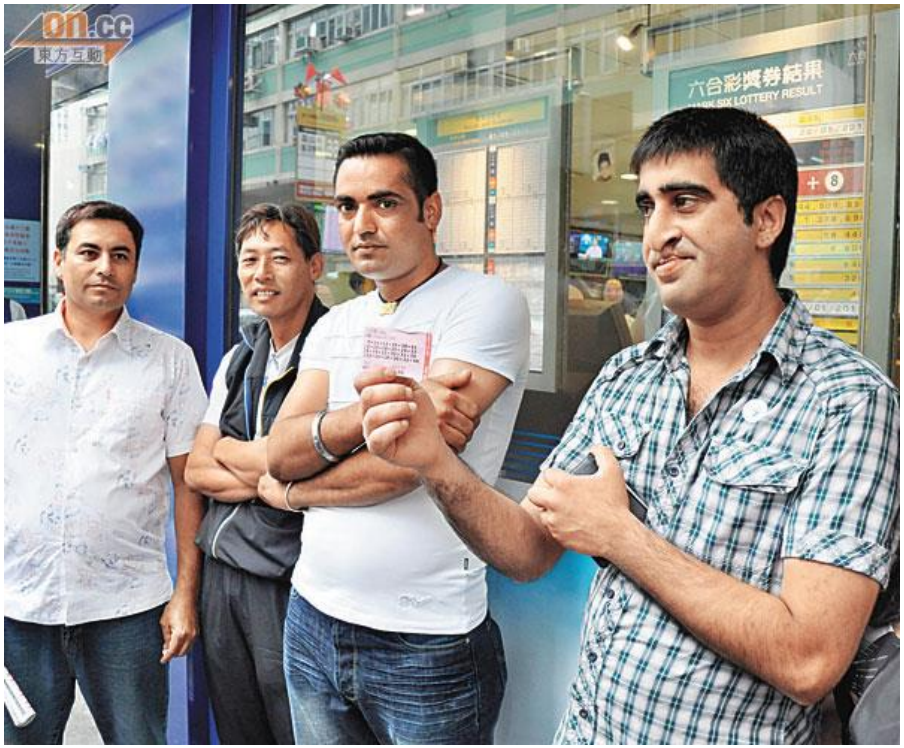
_ _ _ _ _ *n* _ (seven-letter words that have n in the sixth position)

In four pages of an English novel (2000 words), how many words would you expect to find that have the following form?

_ _ _ _ *i n g* (seven-letter words that end with *ing*)

AVAILABILITY BIAS

Judgments regarding likelihood of events tend to be based on how easily instances occurrences of that event can be recalled from memory (influenced by own exposure, stories, media)



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Amazon.com is a reputable company that stand out in customer services. You will have a piece of mind because not only they will make sure you get the holiday gift on time but they are very actively in updating you the status of your gift delivery. Gift wrapping is also available for just a small additional fee.

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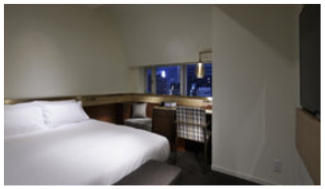
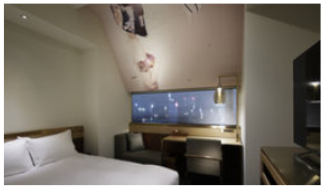
If this is MUST HAVE gift, be sure to order now to avoid disappointment.

EXPEDIA

CHOOSE YOUR ROOM

Check-in: 2015/12/18 | Check-out: 2015/12/20 | Rooms: 1 | Adults: 2 | Children: 0 | UPDATE

Room type	Options	Avg rate per night	
 Best Value! **Economy Double** 15 square meters **1 double bed** **Room sleeps 2 guests** (up to 1 child)	✔ Free Cancellation until Wednesday, 16 Dec ✔ Free Internet ✔ No Expedia booking or credit card fees	Recommended for you 2 rooms left **HK$961.85** ⓘ	BOOK It only takes 2 minutes
	✔ Free Cancellation until Wednesday, 16 Dec ✔ Breakfast Included ✔ Free Internet ✔ No Expedia booking or credit card fees	2 rooms left **HK$1,103.13** ⓘ	BOOK It only takes 2 minutes
 **Deluxe Double** 23 square meters **1 queen bed** **Room sleeps 2 guests** (up to 1 child)	✔ Free Cancellation until Wednesday, 16 Dec ✔ Free Internet ✔ No Expedia booking or credit card fees	1 room left **HK$1,385.69** ⓘ	BOOK It only takes 2 minutes
	✔ Free Cancellation until Wednesday, 16 Dec ✔ Breakfast Included ✔ Free Internet ✔ No Expedia booking or credit card fees	1 room left **HK$1,526.98** ⓘ	BOOK It only takes 2 minutes