Strategic Capacity Management

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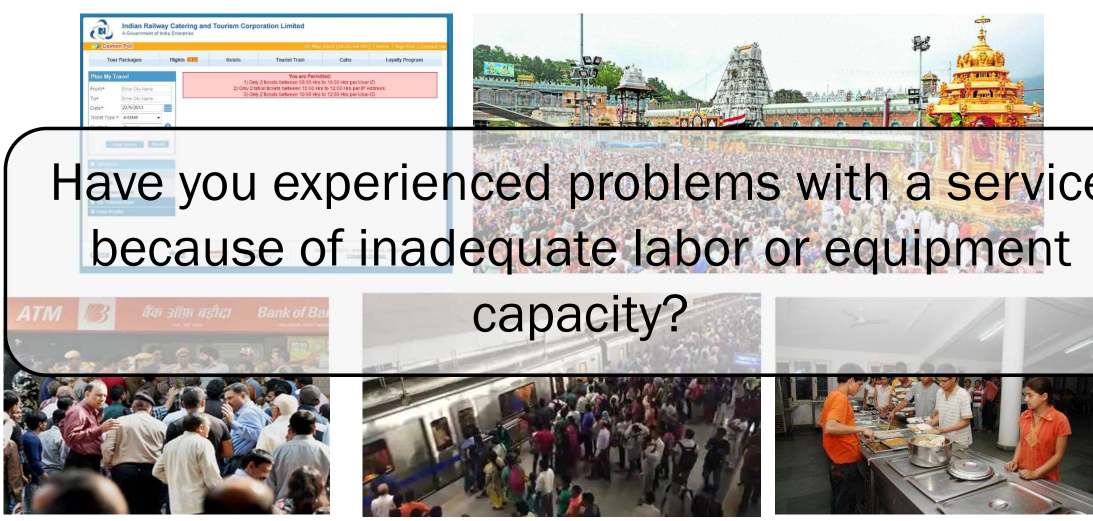
What is common?



Have you experienced problems with a service because of inadequate labor or equipment capacity?

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Capacity

The ability to hold, receive, store, or accommodate

Capacity is the capability of a manufacturing or service resource such as a facility, process, workstation, or piece of equipment to accomplish a purpose over a specific period.

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How do you measure capacity?

PAPER MILL

HOSPITAL

SERVER STORAGE

AUTOMOTIVE PLANT

MAX OUTPUT PER UNIT TIME

UNITS OF RESOURCE AVAILABILITY

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Examples of Short- and Long-Term Capacity Decisions

Short-Term Capacity Decisions	Long-Term Capacity Decisions
• Amount of overtime scheduled for the next week • Number of pizza delivery workers to hire on Super Bowl Sunday • Number of ER nurses on call during a downtown festival weekend • Amount of warehouse space to rent for new promotional items • Number of call center workers to staff during the holiday season	• Construction of a new manufacturing plant • Expanding the size and number of beds in a hospital • Number of branch banks to establish in a new market territory • Closing down a distribution center • Changing the cooking technology in a chain of fast-food restaurants • Adding a 20-ton stamping machine

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Capacity Planning Concepts

- Capacity utilization rate: a measure of how close the firm is to its best possible operating level
  - $Capacity\ Utilization\ rate = \dfrac{Capacity\ used}{Best\ operating\ level}$
- Economies of scale: the idea that as a planet 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

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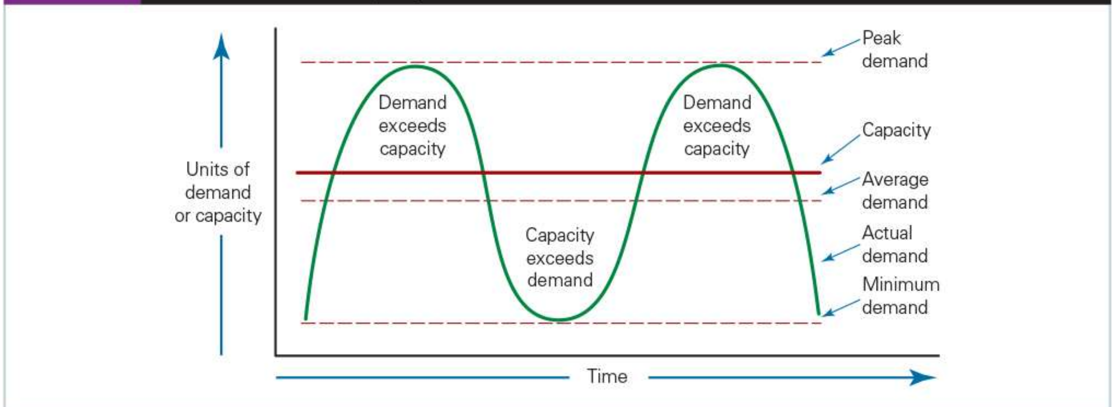
Demand versus Capacity Problem Structure

EXHIBIT 10.2 The Demand Versus Capacity Problem Structure



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Strategic Capacity Planning

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

- Facilities
- Equipment
- Labor force size

Capacity level selected has a critical impact on response rate, it cost structure, is inventory policies, and management and staff support requirements

- Too low and the firm will lose customers and encourage competitors
- Too high and firm may have to cut costs or underutilize its capacity

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- Theoretical Capacity – Maximum Rate of Output
- Actual Capacity – Effective Capacity that can be reasonably be used
- Safety Capacity – Capacity cushion to handle variations

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Work Order

- Specification of work to be performed for a customer or a client
- Includes
  – Quantity to be produced
  – Processing requirements
  – Resources needed

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Capacity Measurement

- Capacity required for one work order (C_i)

  = [Setup time (S_i) + Processing time (P_i)] x order size (Q_i)

  – Where
    - C_i = Capacity requirements in units of time for work order *i*
    - S_i = Setup or changeover time for work order *i* as a fixed amount that does not vary with volume
    - P_i = Processing time for each unit of work order *I*
    - Q_i = Size of order *i* in number of units

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Planning Service Capacity

Manufacturing Capacity	Service Capacity
Goods can be stored for later use	Capacity must be available when service is needed – cannot be stored
Goods can be shipped to other locations	Service must be available at customer demand point
Volatility of demand is relatively low	Much higher volatility is typical

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Capacity Utilization and Service Quality

- Capacity = Service Rate X Number of Servers
- The relationship between service capacity utilization and service quality is critical
  - Arrival rate: the average number of customers that come to a facility during a specific period of time
  - Service rate: the average number of customers that can be processed over the same period of time
  - Best operating point is near 70 percent usually
- 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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Relationship Between the Rate of Service Utilization and Service Quality

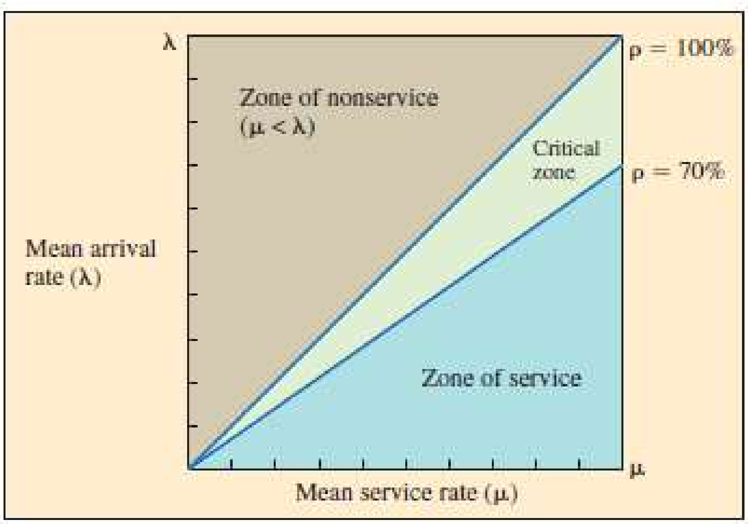

Exhibit 5.6

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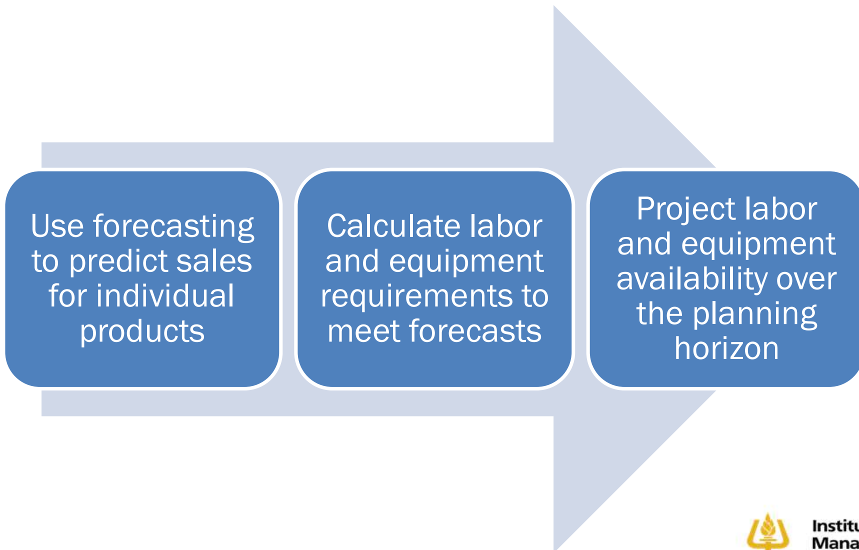
Determining Capacity Requirements



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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
- Have three machines that can package 150,000 bottles each year
  - Each machine requires two operators
- Have five machines that can package 250,000 plastic bags per year
  - Each machine requires three operators
- What are the capacity and labor requirements for the next five years?

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Step 1: Use Forecast 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

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Step 2: Calculate Equipment and Labor Requirements

Bottling Operation

- Capacity: 450,000
  - 150,000 x 3
- Operators: 6
  - 2 x 3
- 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
  - 250,000 x 5
- Operators: 15
  - 3 x 5
- Year 1
  - $Capacity\ utilization = \frac{300}{1{,}250} = 0.24$
  - $Machine\ requirement = 0.24 \times 5 = 1.2$
  - $Labor\ requirement = 1.2 \times 3 = 3.6$

	Year 1	2	3	4	5
Bottles (000s)	135	185	245	297	348
Plastic bags (000s)	300	600	900	1,050	1,180

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Step 3: Project Equipment and Labor Availabilities over the Planning Horizon

	Year				
	1	2	3	4	5
Bottle Operation					
Percentage capacity utilized	30	41	54.4	66	77.3
Machine requirement	0.9	1.23	1.63	1.98	2.32
Labor requirement	1.8	2.46	3.26	3.96	4.64
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

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Long-Term Capacity Strategies

- Addresses the trade-off between the cost of capacity and the opportunity cost of not having adequate capacity
  - Complementary goods and services: Produced or delivered using the same resources available to the firm
    - Seasonal demand patterns of the resources are out of phase with each other
    - Balance seasonal demand cycles by using available excess capacity

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Frequent versus Infrequent Capacity Expansions

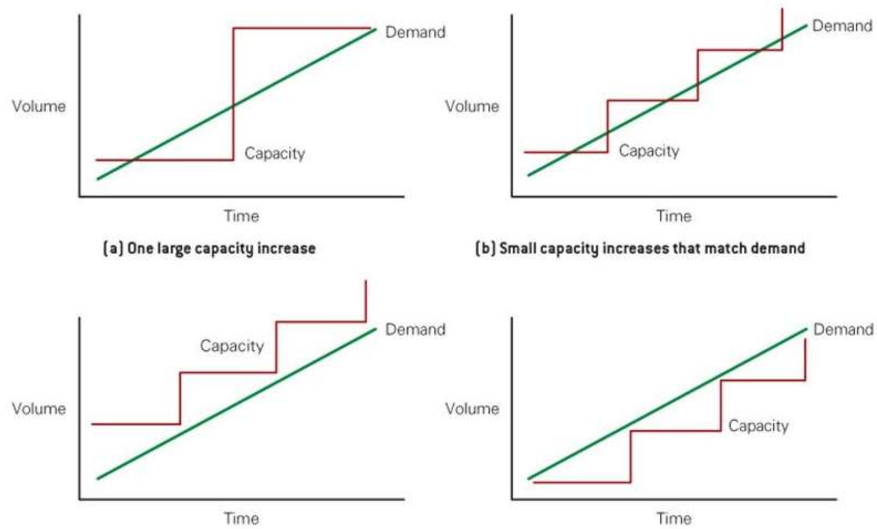

Exhibit 5.2

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Adjusting Short-Term Capacity Levels

- Add or share equipment
- Sell unused capacity
- Change labor capacity and schedules
- Change labor skill mix
- Shift work to slack periods

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Shifting and Stimulating Demand

- Vary the price of goods or services
- Provide customers with information
- Advertising and promotion
- Add peripheral goods and/or services
- Provide reservations
  - Reservation: Promise to provide a good or service at some future time and place

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Revenue Management System (RMS)

- Consists of dynamic methods to:
  - Forecast demand
  - Allocate perishable assets across market segments
  - Decide when to overbook and by how much
  - Determine what price to charge different customer (price) classes

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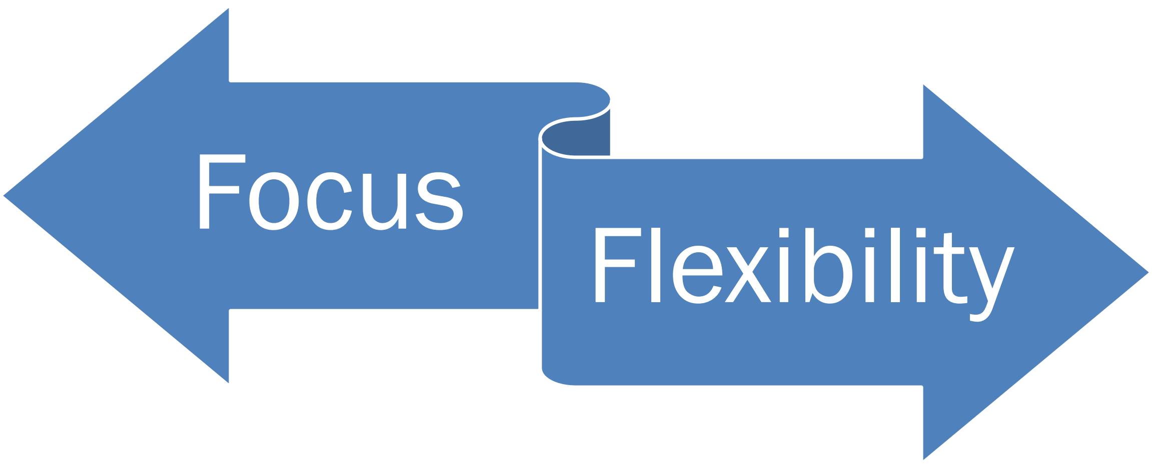
Capacity Management Concepts



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Capacity Focus

- A few key products
- A specific technology
- A certain process design and capability
- A specific competitive priority objective such as next day delivery
- Particular market segments or customers and associated volumes

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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)

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Break-Even Analysis

- Defined as standard approach to choosing among alternative processes or equipment.
- Model seeks to determine the point in units produced where a company will start making profit on the process.
- Model seeks to determine the point in units produced where total revenue and total cost are equal.

$$\text{Breakeven Demand} = \frac{\text{Purchase cost of process or equipment}}{\text{Price per unit - Cost per unit}}$$

or

$$= \frac{\text{Total fixed costs of process or equipment}}{\text{Unit price to customer - Variable cost per unit}}$$

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- The management of a pizza place would like to add a new line of small pizza, which will require leasing a new equipment for a monthly payment of $4,000. Variable costs would be $4 per pizza, and pizzas would retail for $9 each.

1. How many pizzas must be sold per month in order to break even?
2. What would the profit (loss) be if 1200 pizzas are made and sold in a month?
3. How many pizzas must be sold to realize a profit of $10,000 per month?
4. If demand is expected to be 700 pizzas per month, will this be a profitable investment?

1. $Q_{BEP} = FC / (r - v)$ = 4000 / (9 – 4) = 800 pizzas per month
2. total revenue – total cost = 1200 x 9 – 1200 x 4 – 4000 = $2000 (i.e. a profit)
3. P = $10000 = $Q(r - v) - FC$;
   Solving for Q will give us: Q = (10000 + 4000) / (9 – 4) = 2800
4. Producing less than 800 (i.e. Q_{BEP}) pizzas will bring in a loss. Since 700 < 800 (Q_{BEP}), it is not a profitable investment.

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Example 7.1: Break-Even Analysis

- Buy for $200
- Make on lathe for $75
- Make on machining center for $15
- Buy has no fixed costs
- Lathe has $80,000 fixed costs
- Machining center has $200,000 fixed costs

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Example 7.1: Total Cost for Each Option

- Purchase
  Cost = $200 x Demand
- Produce Using Lathe
  Cost = $80,000 + $75 x Demand
- Produce Using Machining Center
  Cost = $200,000 + $15 x Demand

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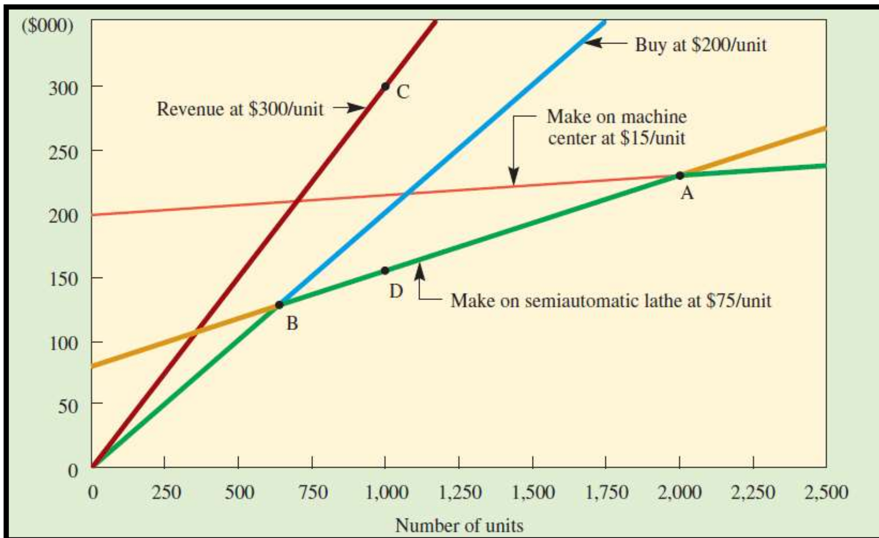
Example 7.1: Costs Shown Graphically



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Example 7.1: Finding Points A and B

Point A

$$\$80,000 + \$75 \cdot Demand = \$200,000 + \$15 \cdot Demand$$

$$\$80,000 + \$60 \cdot Demand = \$200,000$$

$$\$60 \cdot Demand = \$120,000$$

$$Demand = \$120,000 / \$60 = 2,000$$

Point B

$$\$200 \cdot Demand = \$80,000 + \$75 \cdot Demand$$

$$\$125 \cdot Demand = \$80,000$$

$$Demand = \$80,000 / \$125 = 640$$

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Which location should we go for?

- Community A
  - FC/year = $150000
  - VC/unit = $62
- Community B
  - FC/year = $300000
  - VC/unit = $38
- Community C
  - FC/year = $500000
  - VC/unit = $24
- Community D
  - FC/year = $600000
  - VC/unit = $30

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Using Decision Trees to Evaluate Capacity Alternatives

- 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
- Decision tree components include the following:
  - Decision nodes – represented with squares
  - Chance nodes – represented with circles
  - Paths – links between nodes
- Work from the end of the tree backwards to the start of the tree
- Calculate expected values at each step

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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
- 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 = $190,000; weak growth = $100,000
  - Do nothing
    - Payoffs: strong growth = $170,000; weak growth = $105,000

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Calculate the value of each alternative

ALTERNATIVE	REVENUE	COST	VALUE
Move to new location, strong growth	$195,000 × 5 yrs	$210,000	$765,000
Move to new location, weak growth	$115,000 × 5 yrs	$210,000	$365,000
Expand store, strong growth	$190,000 × 5 yrs	$87,000	$863,000
Expand store, weak growth	$100,000 × 5 yrs	$87,000	$413,000
Do nothing now, strong growth, expand next year	$170,000 × 1 yr + $190,000 × 4 yrs	$87,000	$843,000
Do nothing now, strong growth, do not expand next year	$170,000 × 5 yrs	$0	$850,000
Do nothing now, weak growth	$105,000 × 5 yrs	$0	$525,000

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Diagram the Problem Chronologically

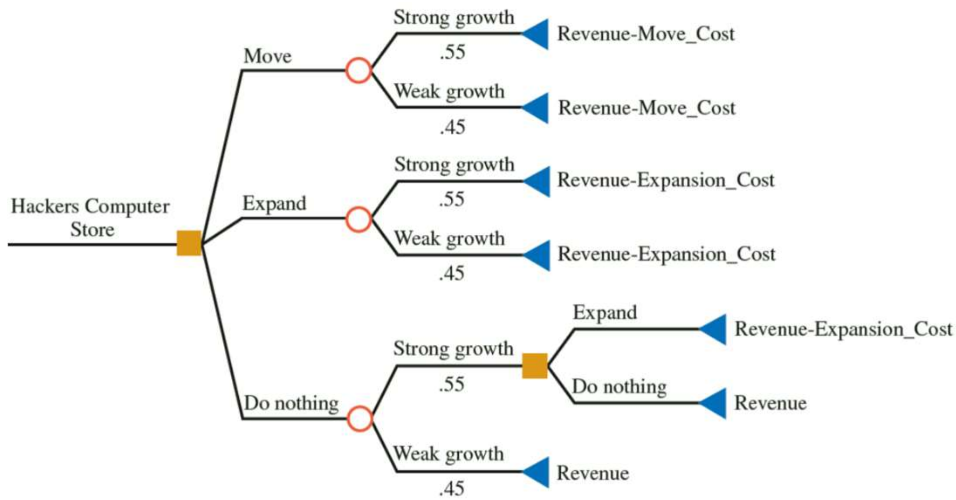

Exhibit 5.3

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Calculate Value of Each Branch

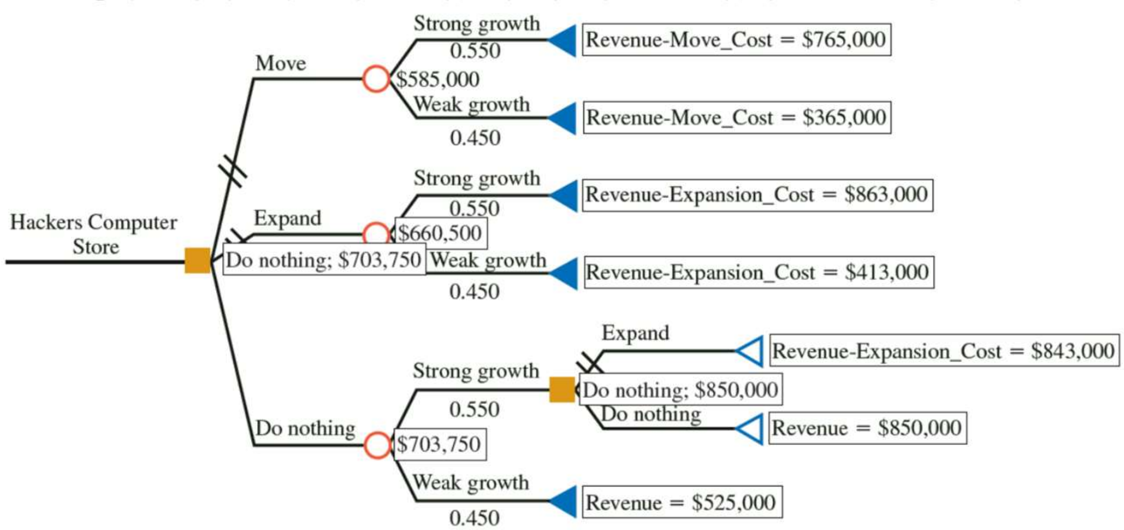

Exhibit 5.4

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Decision Tree Analysis with Net Present Value Calculations

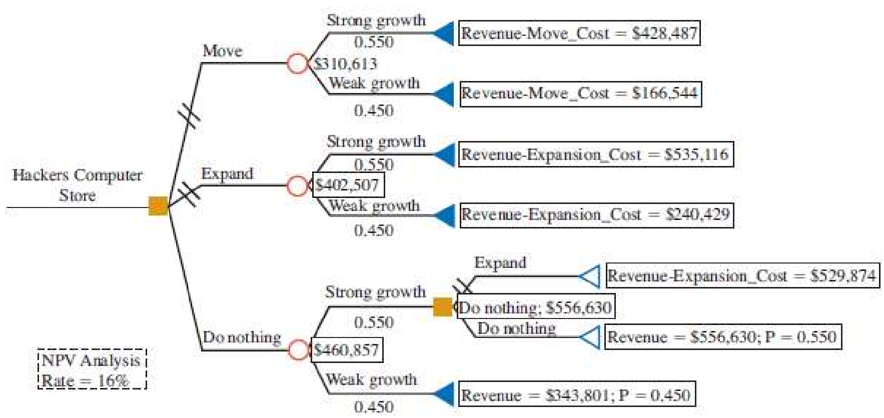

Exhibit 5.5

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