

# Strategic Capacity Planning for Products and Services

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## Lecture 5



# Capacity Planning

- Capacity
  - The upper limit or ceiling on the load that an operating unit can handle
- Capacity needs include
  - Equipment
  - Space
  - Employee skills



# Strategic Capacity Planning

- **Goal**

To achieve a match between the long-term supply capabilities of an organization and the predicted level of long-run demand

- Overcapacity → operating costs that are too high
- Undercapacity → strained resources and possible loss of customers



# Capacity Planning Questions

- Key Questions:
  - **What kind** of capacity is needed?
  - **How much** capacity is needed to match demand?
  - **When** is it needed?
- Related Questions:
  - How much will it cost?
  - What are the potential benefits and risks?
  - Are there sustainability issues?
  - Can the supply chain handle the necessary changes?

# Capacity Decisions are Strategic

- impact the ability of the organization to meet future demands
- affect operating costs
- are a major determinant of initial cost but can be changed
- often involve long-term commitment of resources
- can affect competitiveness
- need to be planned for in advance due to their consumption of financial and other resources

# Capacity



## **Design capacity**

- maximum output rate or service capacity an operation, process, or facility is designed for

## **Effective capacity**

- Design capacity disadvantage allowances such as personal time, maintenance, and scrap

## **Actual output**

- rate of output achieved--cannot exceed effective capacity.

# Measuring System Effectiveness

- **Actual output**
  - The rate of output achieved
  - It cannot exceed effective capacity

- **Efficiency**

$$\text{Efficiency} = \frac{\text{actual output}}{\text{effective capacity}}$$

**Measured as  
percentages**

- **Utilization**

$$\text{Utilization} = \frac{\text{actual output}}{\text{design capacity}}$$

**Waiting line analysis can be useful for capacity design, especially for service systems**

# Example– Efficiency and Utilization

- Design Capacity = 50 trucks per day
- Effective Capacity = 40 trucks per day
- Actual Output = 36 trucks per day

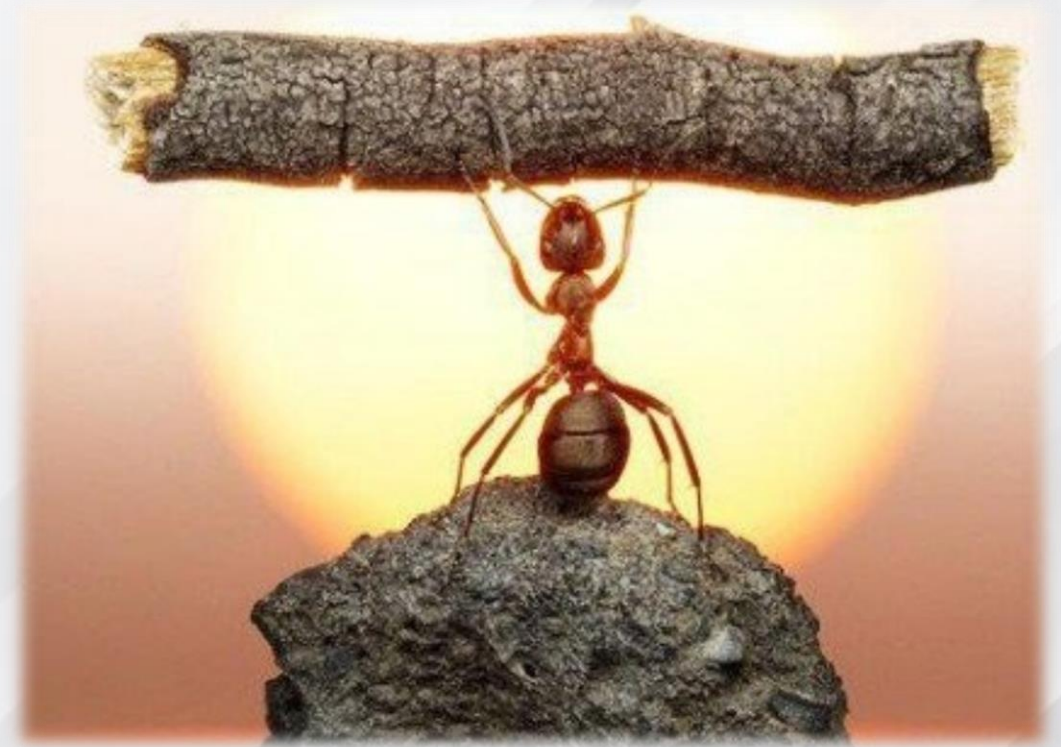
$$\text{Efficiency} = \frac{\text{actual output}}{\text{effective capacity}} = \frac{36}{40} = 90\%$$

$$\text{Utilization} = \frac{\text{actual output}}{\text{design capacity}} = \frac{36}{50} = 72\%$$



# Factors of Effective Capacity

- Facilities
- Product and service factors
- Process factors
- Human factors
- Policy factors
- Supply chain factors
- External factors



**An example of an external factor that influences effective capacity is government safety regulations**

# Capacity Strategies

- **Leading**

- Build capacity in anticipation of future demand increases

- **Following**

- Build capacity when demand exceeds current capacity

- **Tracking**

- Like the following strategy, but adds capacity in relatively small increments to keep pace with increasing demand

# Strategy Formulation

- Strategies are typically based on assumptions and predictions about:
  - Long-term demand patterns
  - Technological change
  - Competitor behavior



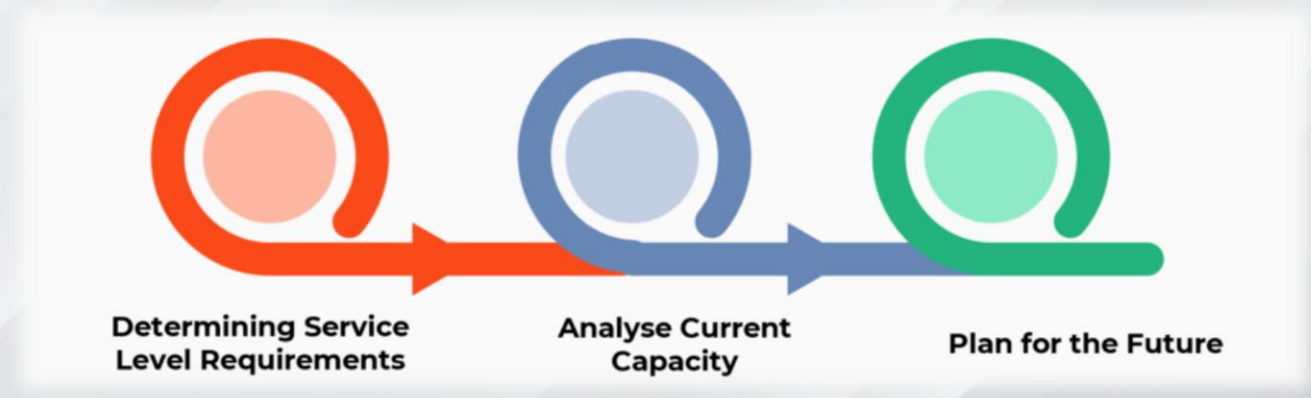
# Capacity Cushion

- Extra capacity used to offset demand uncertainty
- Capacity cushion =  $100\% - \text{Utilization}$
- Capacity cushion strategy
  - Organizations that have greater demand uncertainty typically have greater capacity cushion
  - Organizations that have standard products and services generally have greater capacity cushion



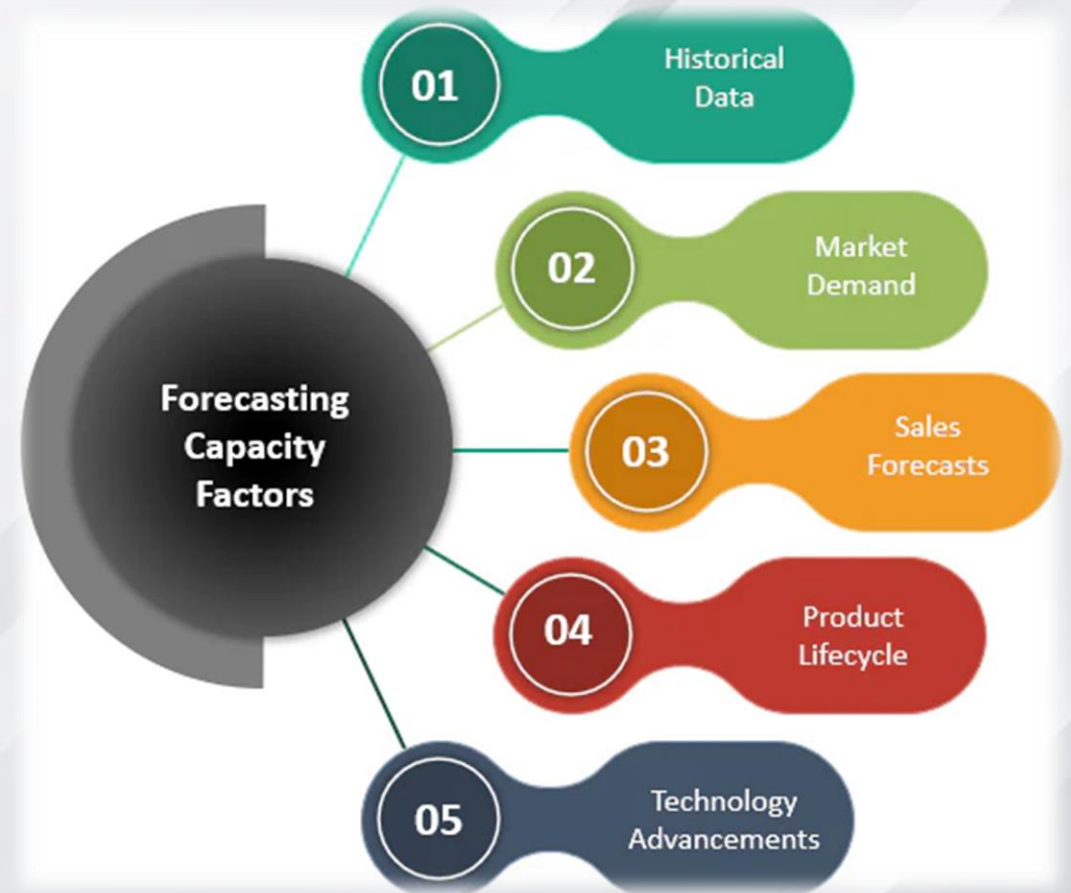
# Steps in Capacity Planning

1. Estimate future capacity requirements
2. Evaluate existing capacity and facilities; identify gaps
3. Identify alternatives for meeting requirements
4. Conduct financial analyses
5. Assess key qualitative issues
6. Select the best alternative for the long term
7. Implement alternative chosen
8. Monitor results



# Forecasting Capacity Requirements

- Long-term considerations relate to overall *level* of capacity requirements
- Short-term considerations relate to probable *variations* in capacity requirements



**Increasing capacity right before an unplanned operation will destruction the process's output**

# Service Capacity Planning

- Service capacity planning can present several challenges related to:
  - **The need to be near customers**
    - Convenience
  - **The inability to store services**
    - Cannot store services for consumption later
  - **The degree of demand volatility**
    - Volume and timing of demand
    - Time required to service individual customers

# **Demand Management Strategies**

- Strategies used to offset capacity limitations and that are intended to achieve a closer match between supply and demand
  - Pricing
  - Promotions
  - Discounts
  - Other tactics to shift demand from peak periods into slow periods

# In-House or Outsource?

- Once capacity requirements are determined, the organization must decide whether to produce a good or service itself or outsource
- Factors to consider:
  - Available capacity
  - Expertise
  - Quality considerations
  - The nature of demand
  - Cost
  - Risks



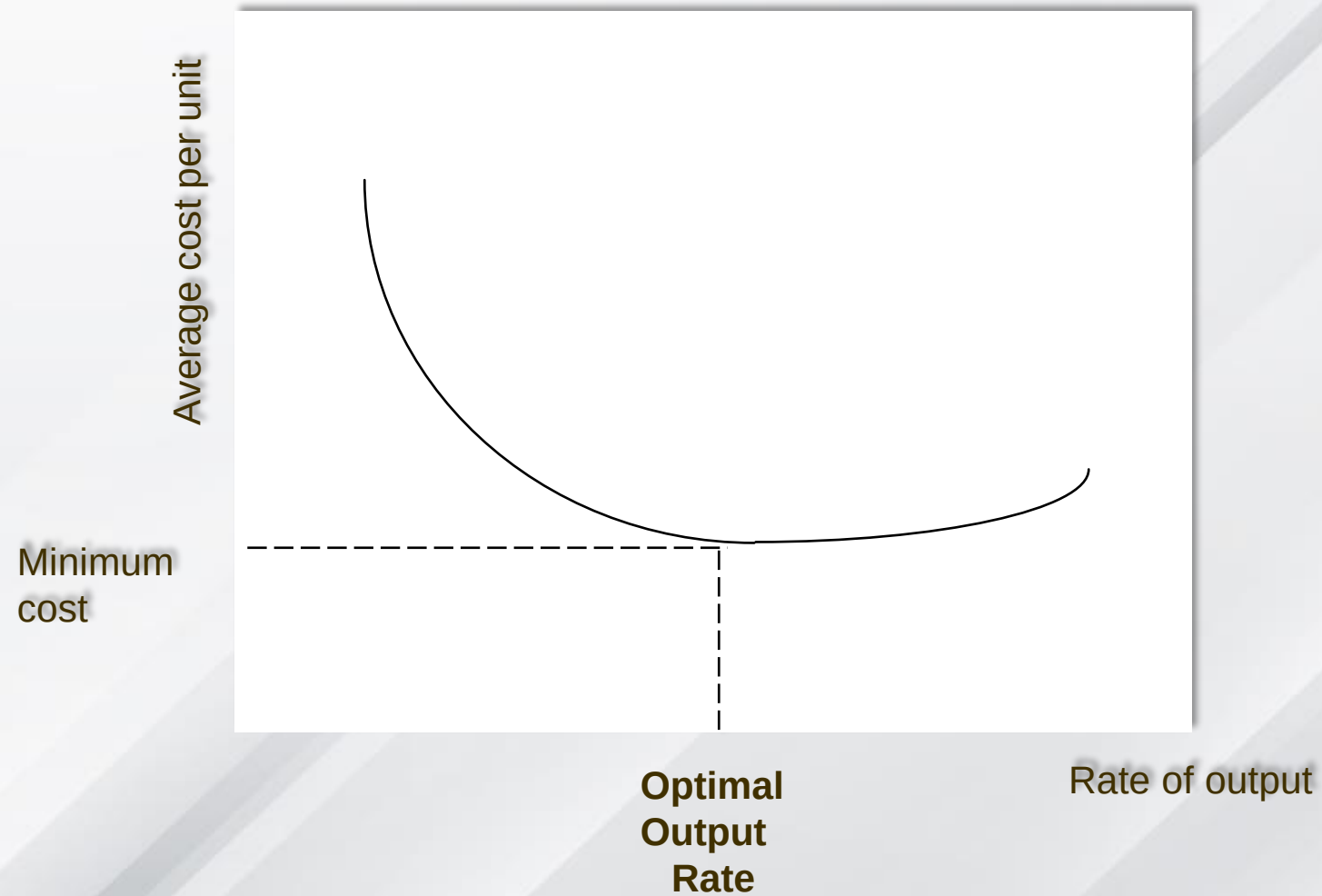
**Increasing productivity and quality will result in increased capacity**

# Developing Capacity Alternatives

- Things that can be done to enhance capacity management
  - Design flexibility
  - Take stage of life cycle into account
  - Take a “big-picture” approach to capacity changes
  - Prepare to deal with capacity “chunks”
  - Attempt to smooth capacity requirements
  - Identify the optimal operating level
  - Choose a strategy if expansion is involved

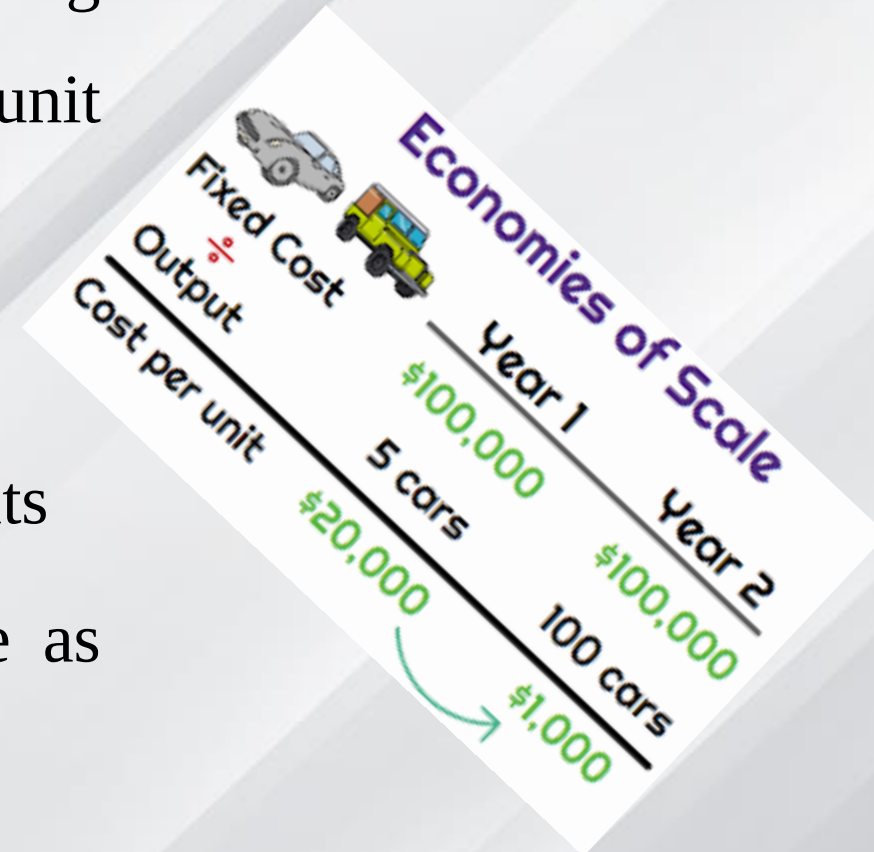


# Optimal Operating Level



# Economies of Scale

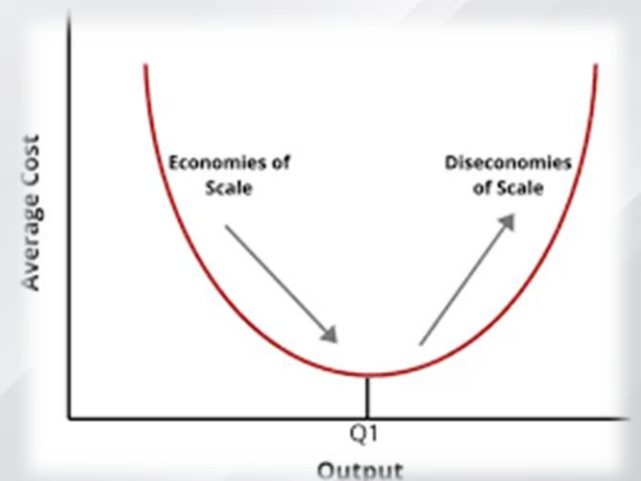
- If output rate is less than the optimal level, increasing the output rate results in decreasing average per unit costs
- Reasons for economies of scale:
  - Fixed costs are spread over a larger number of units
  - Construction costs increase at a decreasing rate as facility size increases
  - Processing costs decrease due to standardization



# Diseconomies of Scale

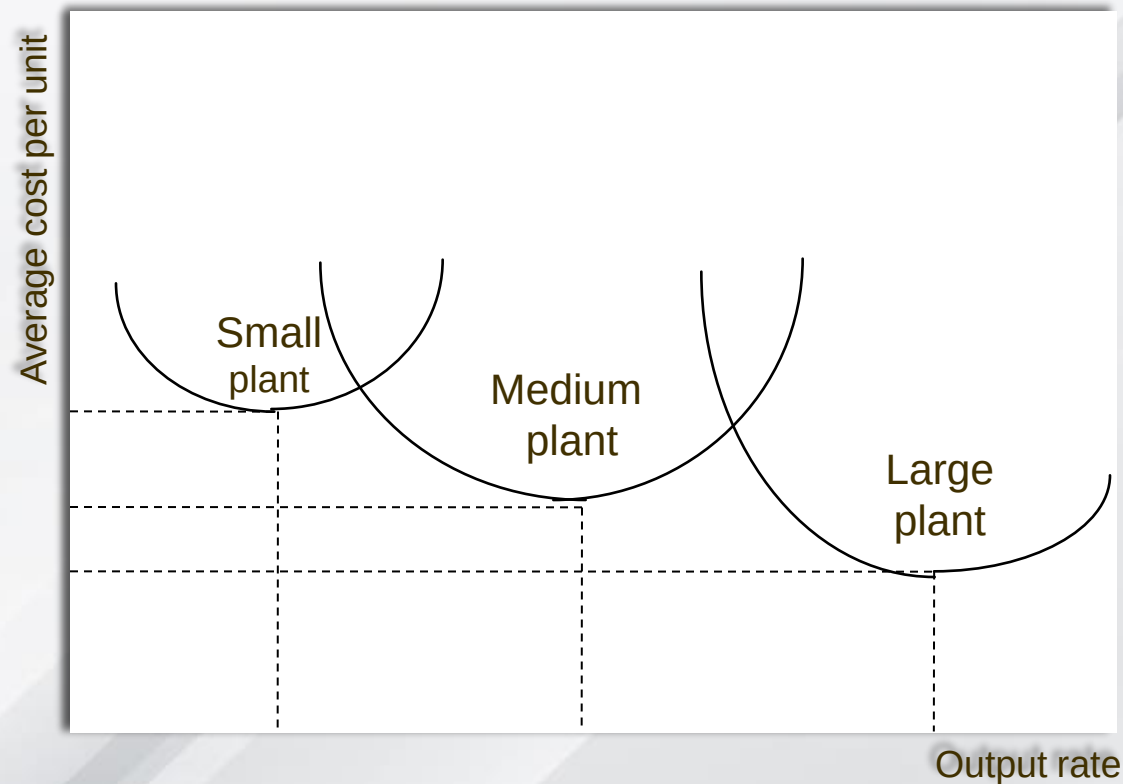
- **Diseconomies of Scale**

- If the output rate is more than the optimal level, increasing the output rate results in increasing average per unit costs
- Reasons for diseconomies of scale
  - Distribution costs increase due to traffic congestion and shipping from a centralized facility rather than multiple smaller facilities
  - Complexity increases costs
  - Inflexibility can be an issue
  - Additional levels of bureaucracy



# Facility Size and Optimal Operating Level

**Minimum cost & optimal operating rate are functions of size of production unit.**



# Constraint Management

Something that limits the performance of a process or system in achieving its goals

- Categories
  - Market
  - Resource
  - Material
  - Financial
  - Knowledge or competency
  - Policy



**Outsourcing some production is a means of supporting a constraint**

# **Resolving Constraint Issues**

1. Identify the most pressing constraint
2. Change the operation to achieve maximum benefit, given the constraint
3. Make sure other portions of the process are supportive of the constraint
4. Explore and evaluate ways to overcome the constraint
5. Repeat the process until the constraint levels are at acceptable levels

# Financial Analysis

- **Cash flow**

- The difference between cash received from sales and other sources, and cash outflow for labor, material, overhead, and taxes

- **Present value**

- The sum, in current value, of all future cash flow of an investment proposal

# Decision Theory

# Decision Theory

- A general approach to decision making that is suitable to a wide range of operations management decisions
  - Capacity planning
  - Product and service design
  - Equipment selection
  - Location planning



# Characteristics of Suitable Problems

- Characteristics of decisions that are suitable for using decision theory
  - A set of possible future conditions that will have a bearing on the results of the decision
  - A list of alternatives from which to choose
  - A known payoff for each alternative under each possible future condition

# **Process for Using Decision Theory**

1. Identify the possible future states of nature
2. Develop a list of possible alternatives
3. Estimate the payoff for each alternative for each possible future state of nature
4. If possible, estimate the likelihood of each possible future state of nature
5. Evaluate alternatives according to some decision criterion and select the best alternative

# Causes of Poor Decisions

- Decisions occasionally turn out poorly due to unforeseeable circumstances; however, this is not the norm.
- More frequently poor decisions are the result of a combination of
  - Mistakes in the decision process
  - Bounded rationality
  - Suboptimization

# Decision Process

## Steps:

1. Identify the problem
2. Specify objectives and criteria for a solution
3. Develop suitable alternatives
4. Analyze and compare alternatives
5. Select the best alternative
6. Implement the solution
7. Monitor to see that the desired result is achieved

## Errors

- Failure to recognize the importance of each step
- Skipping a step
- Failure to admit mistakes

**The greater the gap between the current and desired capacity the greater the opportunity to fail**

# **Bounded Rationality & Suboptimization**

- **Bounded rationality**

- The limitations on decision making caused by costs, human abilities, time, technology, and availability of information

- **Suboptimization**

- The results of different departments each attempting to reach a solution that is optimum for that department

# Decision Environments

- There are three general environment categories:
  - **Certainty**
    - Environment in which relevant parameters have known values
  - **Risk**
    - Environment in which certain future events have probable outcomes
  - **Uncertainty**
    - Environment in which it is impossible to assess the likelihood of various future events



# Decision Making Under Uncertainty

- Decisions are sometimes made under complete uncertainty: No information is available on how likely the various states of nature are.
- Decision Criteria:
  - **Maximin**
    - Choose the alternative with the best of the worst possible payoffs
  - **Maximax**
    - Choose the alternative with the best possible payoff
  - **Laplace**
    - Choose the alternative with the best average payoff
  - **Minimax regret**
    - Choose the alternative that has the least of the worst regrets

# Example – Payoff Table

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| Alternatives    | Possible Future Demand |          |      |
|-----------------|------------------------|----------|------|
|                 | Low                    | Moderate | High |
| Small Facility  | \$10                   | \$10     | \$10 |
| Medium Facility | 7                      | 12       | 12   |
| Large Facility  | (4)                    | 2        | 16   |

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- A decision is being made concerning which size facility should be constructed
- The present value (in millions) for each alternative under each state of nature is expressed in the body of the above payoff table

# Example – Maximin Criterion

| Alternatives    | Possible Future Demand |          |      |
|-----------------|------------------------|----------|------|
|                 | Low                    | Moderate | High |
| Small Facility  | \$10                   | \$10     | \$10 |
| Medium Facility | 7                      | 12       | 12   |
| Large Facility  | (4)                    | 2        | 16   |

- The worst payoff for each alternative is
  - Small facility: \$10 million
  - Medium facility \$7 million
  - Large facility -\$4 million
- Choose to construct a small facility**

# Example – Maximax Criterion

| Alternatives    | Possible Future Demand |          |      |
|-----------------|------------------------|----------|------|
|                 | Low                    | Moderate | High |
| Small Facility  | \$10                   | \$10     | \$10 |
| Medium Facility | 7                      | 12       | 12   |
| Large Facility  | (4)                    | 2        | 16   |

- The best payoff for each alternative is
  - Small facility: \$10 million
  - Medium facility: \$12 million
  - Large facility: \$16 million
- **Choose to construct a large facility**

# Example – Laplace Criterion

| Alternatives    | Possible Future Demand |          |      |
|-----------------|------------------------|----------|------|
|                 | Low                    | Moderate | High |
| Small Facility  | \$10                   | \$10     | \$10 |
| Medium Facility | 7                      | 12       | 12   |
| Large Facility  | (4)                    | 2        | 16   |

- The average payoff for each alternative is

Small facility:  $(10+10+10)/3 = \$10$   
million

Medium facility  $(7+12+12)/3 = \$10.33$  million

Large facility  $(-4+2+16)/3 = \$4.67$  million

- Choose to construct a medium facility

# Example – Minimax Regret

| Alternatives    | Possible Future Demand |          |      |
|-----------------|------------------------|----------|------|
|                 | Low                    | Moderate | High |
| Small Facility  | \$10                   | \$10     | \$10 |
| Medium Facility | 7                      | 12       | 12   |
| Large Facility  | (4)                    | 2        | 16   |

**Construct a regret (or opportunity loss) table**

- The difference between a given payoff and the best payoff for a state of nature

| Alternatives    | Regrets |          |      |
|-----------------|---------|----------|------|
|                 | Low     | Moderate | High |
| Small Facility  | \$0     | \$2      | \$6  |
| Medium Facility | 3       | 0        | 4    |
| Large Facility  | 14      | 10       | 0    |

# Example – Minimax Regret

| Alternatives    | Regrets |          |       |
|-----------------|---------|----------|-------|
|                 | Low     | Moderate | High  |
| Small Facility  | \$0     | \$2      | (\$6) |
| Medium Facility | 3       | 0        | (4)   |
| Large Facility  | (14)    | 10       | 0     |

- Identify the worst regret for each alternative
  - Small facility \$6 million
  - Medium facility \$4 million
  - Large facility \$14 million
- Select the alternative with the minimum of the maximum regrets
  - **Build a medium facility**



**Thank You**