Strategic managerial decisions: Characterized by interactive payoffs in which managers must explicitly consider the actions likely to be taken by their rivals in response to their decisions.

Nonstrategic managerial decisions: Do not involve other decision makers, so the reactions of other decision makers do not have to be considered.
Interactive: When the consequence of a manager’s decision depends on both the manager’s own action and the actions of others.

There are no unconditional optimal strategies in game theory; the optimality of a strategy depends on the situation in which it is implemented.
STRATEGY BASICS

• All game theoretic models are defined by five parameters.

1. The players: A player is an entity that makes decisions; models describe the number and identities of players.

2. The feasible strategy set: Actions with a nonzero probability of occurring comprise the feasible strategy set.
All game theoretic models are defined by five parameters (cont’d).

3. The outcomes or consequences: The feasible strategies of all players intersect to define an outcome matrix.

4. The payoffs: Every outcome has a defined payoff for every player. Players are assumed to be rational, that is, to prefer a higher payoff to a lower one.

5. The order of play: Play may be simultaneous or nonsimultaneous, that is, sequential.
• Matrix form: Form that summarizes all possible outcomes
• Extensive form: Form that provides a road map of player decisions
• Game trees: Game trees are another name for extensive form games and are akin to decision trees.
• Examples
  • Figure 12.1: Two-Person Simultaneous Game
  • Figure 12.2: Allied-Barkley Pricing: Sequential
  • Figure 12.3: Allied-Barkley Pricing: Simultaneous
  • Uses information sets to use the extensive form to represent simultaneous decisions
A Two-Person Simultaneous Game

<table>
<thead>
<tr>
<th>Barkley’s strategy</th>
<th>Allied’s strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spend at current level</td>
<td>Spend at current level</td>
</tr>
<tr>
<td></td>
<td>3, 4</td>
</tr>
<tr>
<td></td>
<td>2, 3</td>
</tr>
<tr>
<td>Increase spending</td>
<td>Increase spending</td>
</tr>
<tr>
<td></td>
<td>4, 3</td>
</tr>
<tr>
<td></td>
<td>3, 2</td>
</tr>
</tbody>
</table>
ALLIED–BARKLEY PRICING: SIMULTANEOUS

FIGURE 12.3

Allied–Barkley Pricing: Simultaneous
Solution Concepts
- The key to the solution of game theory problems is the anticipation of the behavior of others.

Equilibria
- Equilibrium: When no player has an incentive to unilaterally change his or her strategy.
- No player is able to improve his or her payoff by unilaterally changing strategy.
• Dominant strategy: Strategy whose payout in any outcome is higher relative to all other feasible strategies
  • Strategy that is optimal regardless of the strategies selected by rivals
• Example: Dominant strategy
  • Figure 12.1: Two-Person Simultaneous Game
    • Barkley has a dominant strategy, which is to maintain the current spending level.
    • Allied has a dominant strategy, which is to increase spending.
DOMINANT STRATEGIES

- Example: Dominated strategy
  - Figure 12.4: Matrix Form Representation of Figure 12.2
    - Barkley has a dominated strategy, which is to charge $1.00. There is no circumstance under which this strategy would yield a payoff greater than the other feasible strategies.
    - Allied has two dominated strategies, given the elimination of a Barkley price of $1.00. These are to price at $0.95 and to price at $1.30.
  - Figure 12.5: Iterative Dominance
    - Shows the elimination of dominated strategies
Matrix Form Representation of Figure 12.2

<table>
<thead>
<tr>
<th>Barkley’s pricing strategies</th>
<th>$0.95</th>
<th>$1.30</th>
<th>$1.55</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.00</td>
<td>3, 6</td>
<td>7, 1</td>
<td>10, 4</td>
</tr>
<tr>
<td>$1.35</td>
<td>5, 1</td>
<td>8, 2</td>
<td>14, 7</td>
</tr>
<tr>
<td>$1.65</td>
<td>6, 0</td>
<td>6, 2</td>
<td>8, 5</td>
</tr>
</tbody>
</table>
Iterative Dominance

A. Barkley’s $1.00 strategy is eliminated.

<table>
<thead>
<tr>
<th>Barkley’s pricing strategies</th>
<th>Allied’s pricing strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.35</td>
<td>$0.95 5, 1</td>
</tr>
<tr>
<td></td>
<td>$1.30 8, 2</td>
</tr>
<tr>
<td></td>
<td>$1.55 14, 7</td>
</tr>
<tr>
<td>$1.65</td>
<td>$0.95 6, 0</td>
</tr>
<tr>
<td></td>
<td>$1.30 6, 2</td>
</tr>
<tr>
<td></td>
<td>$1.55 8, 5</td>
</tr>
</tbody>
</table>

B. Allied’s $0.95 and $1.30 strategies are eliminated.

<table>
<thead>
<tr>
<th>Barkley’s pricing strategies</th>
<th>Allied’s pricing strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.35</td>
<td>$1.55 14, 7</td>
</tr>
<tr>
<td>$1.65</td>
<td>$1.55 8, 5</td>
</tr>
</tbody>
</table>
Assuming that all players are rational, every player should choose the best strategy conditional on all other players doing the same.
The Nash Equilibrium

- **Model**
  - Each of N players chooses a strategy $s_i^*$, where $i = 1, 2, 3, N$.
  - An outcome of the game is represented as an array of strategies $s^* = (s_1^*, s_2^*, s_N^*)$.
  - The payoff to player i when $s^*$ is selected is $B(s^*)$.
  - A Nash equilibrium is an array of strategies such that $B_i(s_1^*, s_2^*, s_N^*) \geq B_i(s_1', s_2^*, s_N^*)$ for all outcomes.
    - There is no array of strategies better than $s^*$ for any player.
    - This equilibrium is rational, optimal, and stable.
• Figure 12.6: New Product Introduction
  • Nash equilibrium is where Barkley produces product sigma and Allied produces product alpha.
### New Product Introduction

<table>
<thead>
<tr>
<th>Barkley</th>
<th>Product lambda</th>
<th>Product pi</th>
<th>Product sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Allied</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product alpha</td>
<td>4, 6</td>
<td>6, 8</td>
<td>9, 8</td>
</tr>
<tr>
<td>Product beta</td>
<td>9, 8</td>
<td>8, 9</td>
<td>7, 8</td>
</tr>
<tr>
<td>Product zeta</td>
<td>6, 10</td>
<td>7, 7</td>
<td>5, 5</td>
</tr>
</tbody>
</table>
### New Product Introduction with Other’s Behavior

<table>
<thead>
<tr>
<th>Barkley</th>
<th>Product lambda</th>
<th>Product pi</th>
<th>Product sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Product alpha</td>
<td>Product beta</td>
<td>Product zeta</td>
</tr>
<tr>
<td></td>
<td>4, 6</td>
<td>(B) 9, 8</td>
<td>6, 10 (A)</td>
</tr>
<tr>
<td></td>
<td>6, 8</td>
<td>8, 9 (A)</td>
<td>(B) 7, 8</td>
</tr>
<tr>
<td></td>
<td>(B) 9, 8 (A)</td>
<td>7, 7</td>
<td>5, 5</td>
</tr>
</tbody>
</table>
### Payoffs for Each Customer From Using FedEx/UPS and/or DHL

<table>
<thead>
<tr>
<th>Customer A</th>
<th>Customer B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use FedEx/UPS</td>
<td>100, 100</td>
</tr>
<tr>
<td>Use DHL</td>
<td>90, 90</td>
</tr>
</tbody>
</table>
Payoffs for Each Customer From Using FedEx/UPS and/or DHL after DHL Lowers Rates

<table>
<thead>
<tr>
<th>Customer A</th>
<th>Use FedEx/UPS</th>
<th>Use DHL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use FedEx/UPS</td>
<td>100, 100</td>
<td>100$^+$, 100$^+$</td>
</tr>
<tr>
<td>Use DHL</td>
<td>100$^+$, 100$^+$</td>
<td>130$^+$, 130$^+$</td>
</tr>
</tbody>
</table>
STRATEGIC FORESIGHT: THE USE OF BACKWARD INDUCTION

• Definitions

• Strategic foresight: Manager’s ability to make decisions today that are rational given what is anticipated in the future

• Backward induction: Used in game theory to solve games by looking to the future, determining what strategy players will choose (anticipation), and then choosing an action that is rational, based on those beliefs

• In sequential games, backward induction involves starting with the last decisions in the sequence and then working backward to the first decisions, identifying all optimal decisions.
• Example
  • Figure 12.10: Allied-Barkley Expansion
ALLIED–BARKLEY EXPANSION DECISION

FIGURE 12.10

Allied–Barkley Expansion Decision

- **Barkley**
  - **Expand**
    - **Allied**
      - **No expansion**
        - 80, 80
      - **Expand**
        - 60, 120
  - **No expansion**
    - 150, 60
    - 50, 50
• The Credibility of Commitments
  • Credible: When the costs of falsely making a commitment are greater than the associated benefits
STRATEGIC FORESIGHT: THE USE OF BACKWARD INDUCTION

The Credibility of Commitments (cont’d)

- Example
  - Figure 12.12: Does Barkley Have a Credible Threat?
  - It is not in Barkley's interest to drop price in response to Allied’s price cut. The threat to do so is not credible.
FIGURE 12.12

Does Barkley Have a Credible Threat?

- **Allied**
  - **Maintain price**: 30, 50
  - **Drop price**: 20, 70

- **Barkley**
  - **Maintain price**: 40, 30
  - **Drop price**: 15, 20
• Prisoner’s Dilemma
  • Allied and Barkley produce an identical product and have similar cost structures.
  • Each player must decide whether to price high or low.
  • Figure 12.13: Pricing as a Prisoner's Dilemma
    • The solution is for both to price low.
    • Both would be better off if both priced high.
### Pricing as a Prisoner’s Dilemma

<table>
<thead>
<tr>
<th>Barkley’s pricing strategies</th>
<th>Allied’s pricing strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Price high</td>
</tr>
<tr>
<td>Price high</td>
<td>5, 5</td>
</tr>
<tr>
<td>Price low</td>
<td>20, 1</td>
</tr>
</tbody>
</table>
• Prisoner’s Dilemma (cont’d)

• Repeated play can lead to cooperative behavior in a prisoner’s dilemma game.
  • Trust, reputation, promises, threats, and reciprocity are relevant only if there is repeated play.
  • Cooperative behavior is more likely if there is an infinite time horizon than if there is a finite time horizon.
  • If there is a finite time horizon, then the value of cooperation, and hence its likelihood, diminishes as the time horizon is approached. Backward induction implies that cooperation will not take place in this case.
REPEATED GAMES

- Prisoner’s Dilemma (cont’d)
  - Folk theorem: any type of behavior can be supported by an equilibrium (as long as the players believe there is a high probability that future interaction will occur).
Incomplete information games (IIG): A branch of game theory that loosens the restrictive assumption that all players have the same information.

- Asymmetric information is summarized in terms of player types. A type has characteristics unknown to other players that have different preference (payoff) functions.
  - Low-cost type and high-cost type
  - Tough type and soft type
INCOMPLETE INFORMATION GAMES

• **Example**
  
  • **Figure 12.14: Tough or Soft Barkley Managers**
    
    • If Barkley managers are tough, they will fight, and Allied will not enter the market.
    
    • If Barkley managers are soft, they will not fight, and Allied will enter the market.
  
  • **Tit for tat: Strategy in which players cooperate in the first period, and in all succeeding periods the players mimic the strategy of the other player in the preceding period.**
## Tough or Soft Barkley Managers

**A.** Barkley managers are tough.

<table>
<thead>
<tr>
<th>Barkley’s strategies</th>
<th>Allied’s strategies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enter the market</td>
<td>Do not enter the market</td>
</tr>
<tr>
<td>Fight (price low)</td>
<td>6, 2</td>
<td>8, 3</td>
</tr>
<tr>
<td>No fight (price high)</td>
<td>5, 4</td>
<td>2, 3</td>
</tr>
</tbody>
</table>

**B.** Barkley managers are soft.

<table>
<thead>
<tr>
<th>Barkley’s strategies</th>
<th>Allied’s strategies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enter the market</td>
<td>Do not enter the market</td>
</tr>
<tr>
<td>Fight (price low)</td>
<td>2, 2</td>
<td>3, 3</td>
</tr>
<tr>
<td>No fight (price high)</td>
<td>4, 4</td>
<td>7, 3</td>
</tr>
</tbody>
</table>
REPUTATION BUILDING

• Reputation is a rent-generating asset.
  • Reputation requires a time horizon and incomplete information.
  • Reputation is based on a player’s history of behavior and involves inferring future behavior based on past behavior.
CAN RATING AGENCIES IMPROVE A BANK’S CAPITAL STRUCTURE?

<table>
<thead>
<tr>
<th></th>
<th>HIGH capital</th>
<th>LOW capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH capital</td>
<td>50, 50</td>
<td>10, 60</td>
</tr>
<tr>
<td>LOW capital</td>
<td>60, 10</td>
<td>20, 20</td>
</tr>
</tbody>
</table>
CAN RATING AGENCIES IMPROVE A BANK’S CAPITAL STRUCTURE?

<table>
<thead>
<tr>
<th></th>
<th>High Capital</th>
<th>Low Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bank A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High Capital</strong></td>
<td>50, 50</td>
<td>10, 45</td>
</tr>
<tr>
<td><strong>Low Capital</strong></td>
<td>45, 10</td>
<td>5, 5</td>
</tr>
<tr>
<td><strong>Bank B</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Coordination games have more than one Nash equilibrium, and the players’ problem is which one to select.

Matching Games

- Two Nash equilibria
- Problems in coordination arise from players’ inability to communicate, players with different strategic models, and asymmetric information.
• Matching Games (cont’d)
  • Figure 12.15: Product Coordination Game
    • Nash equilibrium is for one firm to produce for the industrial market and the other firm to produce for the consumer market.
    • Both firms would prefer the equilibrium with the higher payoff.
### Product Coordination Game

<table>
<thead>
<tr>
<th>Barkley’s strategies</th>
<th>Allied’s strategies (Produce for consumer market)</th>
<th>Allied’s strategies (Produce for industrial market)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce for consumer market</td>
<td>0, 0</td>
<td>7, 7</td>
</tr>
<tr>
<td>Produce for industrial market</td>
<td>12, 12</td>
<td>0, 0</td>
</tr>
</tbody>
</table>
• Battle of the Sexes
  • Two Nash equilibria
  • Players prefer different equilibria.
  • Figure 12.16: Battle of the Sexes
    • Nash equilibrium is for to one to produce the high-end product and the other to produce the low-end product.
    • Both players prefer to produce the high-end product.
Battle of the Sexes

<table>
<thead>
<tr>
<th>Barkley’s strategies</th>
<th>Allied’s strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-end product</td>
<td>High-end product</td>
</tr>
<tr>
<td>0, 0</td>
<td>11, 6</td>
</tr>
<tr>
<td>Low-end product</td>
<td>Low-end product</td>
</tr>
<tr>
<td>6, 11</td>
<td>0, 0</td>
</tr>
</tbody>
</table>
COORDINATION GAMES

• Figure 12.17: Stag Hunt or Assurance Games

• Outcome (12, 12) is Pareto dominant, since both players are better off, but it is risk dominated because if one firm decides to shift and the other does not, then the player that shifts receives a payoff of zero.

• Achieving the Pareto-dominant solution requires cooperation and trust because of the risk of reneging.
### Stag Hunt or Assurance Game

**FIGURE 12.17**

<table>
<thead>
<tr>
<th>Barkley’s strategies</th>
<th>Allied’s strategies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay with old standard</td>
<td>Stay with old standard</td>
<td>6, 6</td>
</tr>
<tr>
<td>Shift to new standard</td>
<td>Shift to new standard</td>
<td>6, 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0, 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12, 12</td>
</tr>
</tbody>
</table>
• First-Mover Games
  • Two Nash equilibria
  • Players prefer different equilibria.
  • Figure 12.18 First-Mover Advantage
    • Nash equilibrium is for one firm to produce the superior product and the other to produce the inferior product.
    • Both firms want to produce the superior product, which yields the higher payoff, by moving first.
    • Barkley is predicted to move first because the payoff is higher for Barkley and therefore Barkley can afford to spend more to speed up development.
# First-Mover Advantage

<table>
<thead>
<tr>
<th>Barkley’s strategies</th>
<th>Allied’s strategies</th>
<th>Produce superior product</th>
<th>Produce inferior product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce superior product</td>
<td>25, 50</td>
<td>110, 70</td>
<td></td>
</tr>
<tr>
<td>Produce inferior product</td>
<td>30, 140</td>
<td>20, 30</td>
<td></td>
</tr>
</tbody>
</table>
COORDINATION GAMES

- First-Mover Games
  - Hawks and Doves
    - Two Nash equilibria
    - Players prefer different equilibria.
    - Figure 12.19: Hawks and Doves
      - Nash equilibrium is for one player to behave like a hawk and the other to behave like a dove.
      - Both players want to behave like a hawk, which yields the higher payoff.
      - If both players act like hawks, conflict ensues.
Hawks and Doves

**Country 1 strategy**
- Act like a hawk: 
  - Act like a hawk: $-1, -1$
  - Act like a dove: $10, 0$
- Act like a dove: 
  - Act like a hawk: $0, 10$
  - Act like a dove: $5, 5$
Zero-sum games: A competitive game in which any gain by one player means a loss by another player.

Figure 12.20: Advertising Campaigns

Nash equilibrium is for Barkley to choose campaign 2 and for Allied to choose campaign A.
### Advertising Campaigns

<table>
<thead>
<tr>
<th></th>
<th>Campaign A</th>
<th>Campaign B</th>
<th>Campaign C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Campaign 1</strong></td>
<td>-5, 5</td>
<td>20, -20</td>
<td>-22, 22</td>
</tr>
<tr>
<td><strong>Campaign 2</strong></td>
<td>-3, 3</td>
<td>7, -7</td>
<td>4, -4</td>
</tr>
<tr>
<td><strong>Campaign 3</strong></td>
<td>-4, 4</td>
<td>-6, 6</td>
<td>17, -17</td>
</tr>
</tbody>
</table>