OVERVIEW

This chapter is devoted to a more detailed examination of game theory. Game theory is an important tool for analyzing strategic behavior, is concerned with how individuals make decisions when they recognize that their actions affect, and are affected by, the actions of other individuals or groups. Strategic behavior recognizes that the decision-making process is frequently mutually interdependent.

Game theory is the study of the strategic behavior involving the interaction of two or more individuals, teams, or firms, usually referred to as players. Two game theoretic scenarios were examined in this chapter: Simultaneous-move and multi-stage games. In simultaneous-move games the players effectively move at the same time. A normal-form game summarizes the players, possible strategies and payoffs from alternative strategies in a simultaneous-move game.

Simultaneous-move games may be either noncooperative or cooperative. In contrast to noncooperative games, players of cooperative games engage in collusive behavior. A Nash equilibrium, which is a solution to a problem in game theory, occurs when the players' payoffs cannot be improved by changing strategies.

Simultaneous-move games may be either one-shot or repeated games. One-shot games are played only once. Repeated games are games that are played more than once. Infinitely-repeated games are played over and over again without end. Finitely-repeated games are played a limited number of times. Finitely-repeated games have certain or uncertain ends.
Analytically, there is little difference between infinitely-repeated games and finitely-repeated games with an uncertain end. With infinitely-repeated games, and finitely-repeated games with an uncertain end, collusive agreements between and among the players are possible, although not necessarily stable. The solution to a finitely-repeated game with a certain end collapses into a series of noncooperative, one-shot games. Collusive agreements between and among players of finitely-repeated games are inherently unstable.

Multistage games differ from simultaneous-move games in that the play is sequential. An extensive-form game summarizes the players, the information available to each player at each stage, the order of the moves, and the payoffs from alternative strategies of a multistage game. A Nash equilibrium in a multistage game is a subgame perfect equilibrium. In this case, no player is able to improve upon his or her payoff at any stage of the game by switching strategies. Backward induction is a solution concept for finding optimal solutions to multistage games involving multiple Nash equilibria.

Bargaining is a version of a multistage game. Bargaining without impatience assumes that negotiators do not incur costs by not immediately reaching an agreement. Using capital budgeting terminology, the discount rate for finding the present value of future payoffs is zero. The final outcome of this class of bargaining processes depends crucially on who makes the first offer, and on the number of rounds of offers. Players that make the final offer in negotiations have a last-mover’s advantage and are able to extract the entire gains from trade.

Bargaining with impatience assumes that negotiators do incur costs when agreements are not immediately reached. Impatience may be symmetric or asymmetric. Symmetric impatience assumes that the costs to the negotiators from not immediately reaching an agreement are identical. In this case, the discount rate for finding the present value of a future settlement is the same for both players. Asymmetric impatience assumes that this discount rate is different for each player. Players with greater patience (lower discount rate) have the advantage in the negotiating process. In both cases, the player with the final move will receive most of the gains from trade. The extent of this gain will depend upon the relative degrees of impatience of the negotiators. The greater a negotiator’s patience the larger will be that player’s gain from trade.
MULTIPLE CHOICE QUESTIONS

13.1 Game theory:
A. Analyzes strategic interaction among rivals.
B. Examines pricing behavior of firms in perfectly-competitive industries.
C. Examines output decisions of rival firms in all industries.
D. Is only useful for examining moves and counter-moves of players in sequential-move games.
E. None of the above.

13.2 Strategic interaction:
I. Is more pronounced the larger the number of firms in an industry.
II. Is a distinguishing characteristic of industries with a large number of firms, but in which a relatively few large firms dominate industry output.
III. Is more pronounced the fewer the number of firms in an industry.

Which of the following is correct?
A. I only.
B. II only.
C. III only.
D. I and II only.
E. II and III only.

13.3 Simultaneous-move games are sometimes referred to as:
A. Noncooperative games.
B. Dynamic games.
C. Static games.
D. Normal-form games.
E. Bargaining strategies.

13.4 A two-player, simultaneous-move games is one in which the players move:
A. At the same time.
B. At different times, without knowledge of the other player’s move.
C. At different times, but are aware of the other player’s move.
D. Sequentially.
E. All of the above.
13.5 An example of a simultaneous-move game is:
A. Chess.
B. Checkers.
C. Rock-scissors-paper.
D. Mah Jongg.
E. Stratego.

13.6 The modern version of the game theory can be traced to the groundbreaking work of:
A. Konami and Atari.
B. Martin and Lewis.
C. Siegfried and Roy.
D. Von Neumann and Morgenstern.
E. Erickson and Defoe.

13.7 In game theory, a strategy:
A. Is made up of a series of countermoves.
B. Is a decision rule that identifies a player’s moves.
C. Constitutes a multi-stage game.
D. Must be strictly dominant.
E. Must have a Nash equilibrium.

13.8 A normal-form game summarizes:
A. Players, alternative strategies, and payoffs.
B. Players, alternative strategies, and order of moves.
C. Alternative strategies, payoffs, and order of moves.
D. Players, order of moves, and payoffs.
E. Players, stages of the game, and payoffs.

13.9 The alternative combinations of strategies is referred to as a:
A. Payoff matrix.
B. Nash equilibria.
C. Focal-point equilibria.
D. Normal-form game.
E. Strategy profile.

13.10 A Nash equilibrium:
A. Results in a payoff for a player that is no lower than any other payoff, regardless of the strategy adopted by the other players.
B. Results in the largest payoff for both players.
C. Occurs when each player adopts a strategy that it believes is the best response to the other player’s strategy.
D. Results in the best of the worst possible payoffs.
13.11 A secure strategy is:
A. The best of two dominant strategies.
B. The worst of two dominant strategies
C. The strategy that results in the best of the worst possible payoffs.
D. A maximin strategy.
E. Both C and D are correct.

\[
\begin{array}{c|cc}
   & B1 & B2 \\
\hline
A1 & (5, 5) & (3, 0) \\
A2 & (0, 3) & (1, 1) \\
\end{array}
\]

Payoffs: (Player A, Player B)

FIGURE 1

13.12 Refer to Figure 1, which represents a simultaneous-move, non-cooperative, one-shot game. In the matrix, larger payoffs are preferred. Which player has a strictly-dominant strategy?
A. Player A
B. Player B
C. Both players
D. Neither player

13.13 Refer to Figure 1, which represents a simultaneous-move, non-cooperative, one-shot game. In the matrix, larger payoffs are preferred. A Nash equilibrium occurs at the strategy profile:
A. \{A1, B1\}.
B. \{A1, B2\}.
C. \{A2, B1\}.
D. \{A2, B2\}.

13.14 Refer to Figure 1, which represents a simultaneous-move, non-cooperative, one-shot game. If both players adopt a maximin strategy, then the strategy profile for this game is:
A. \{A1, B1\}.
B. \{A1, B2\}.
C. \{A2, B1\}.
D. \{A2, B2\}.
13.15 Suppose that both players in a simultaneous-move, non-cooperative, one-shot game have a strictly-dominant strategy. The solution to this game is a:

I. Nash equilibrium.
II. Strictly-dominant-strategy equilibrium.
III. Market equilibrium.

Which of the following is correct?
A. I only.
B. II only.
C. III only.
D. I and II only.
E. I and III only.

<table>
<thead>
<tr>
<th>Firm B</th>
<th>Raise Price</th>
<th>Lower Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm A</td>
<td>Raise Price</td>
<td>($300, 350$)</td>
</tr>
<tr>
<td></td>
<td>Lower Price</td>
<td>($400, -150$)</td>
</tr>
</tbody>
</table>

Payoffs: (Firm A, Firm B)

13.16 Refer to Figure 2, which summarizes the payoffs in thousands of dollars to two firms in a duopolistic industry arising from alternative pricing strategies. Assume that this is a simultaneous-move, non-cooperative, one-shot game. Which firm has a strictly-dominant strategy?
A. Firm A
B. Firm B
C. Both firms
D. Neither firm

13.17 Refer to Figure 2, which summarizes the payoffs in thousands of dollars to two firms in a duopolistic industry arising from alternative pricing strategies. Assume that this is a simultaneous-move, non-cooperative, one-shot game. A Nash equilibrium occurs at the strategy profile:
A. [{Raise Price, Raise Price}].
B. [{Raise Price, Lower Price}].
C. [{Lower Price, Raise Price}].
D. [{Lower Price, Lower Price}].
13.18 Refer to Figure 2, which summarizes the payoffs in thousands of dollars to two firms in a duopolistic industry arising from alternative pricing strategies. Assume that this is a simultaneous-move, cooperative, one-shot game. The strategy profile for this game is:
A. \{Raise Price, Raise Price\}.
B. \{Raise Price, Lower Price\}.
C. \{Lower Price, Raise Price\}.
D. \{Lower Price, Lower Price\}.

13.19 Refer to Figure 2, which summarizes the payoffs in thousands of dollars to two firms in a duopolistic industry arising from alternative pricing strategies. Assume that this is a simultaneous-move, cooperative, infinitely-repeated game. The strategy profile for this game is:
A. \{Raise Price, Raise Price\}.
B. \{Raise Price, Lower Price\}.
C. \{Lower Price, Raise Price\}.
D. \{Lower Price, Lower Price\}.

13.20 The Snake River Company and the Loblolly River Company are considering their respective advertising campaigns. Figure 3 summarizes the possible payoffs in thousands of dollars to each company from each combination of advertising strategies. What is the Nash equilibrium for this game?
A. \{Television, Radio\}
B. \{Television, Magazines\}
C. \{Newspapers, Radio\}
D. \{Newspapers, Magazines\}
13.21 The Snake River Company and the Loblolly River Company are considering their respective advertising campaigns. Figure 4 summarizes the possible payoffs in thousands of dollars to each company from each combination of advertising strategies. Which firm has a strictly-dominant strategy?
A. Snake  
B. Loblolly  
C. Snake and Loblolly  
D. Neither Snake nor Loblolly

13.22 Consider Figure 4. The solution profile for this game is:
A. {Television, Radio}  
B. {Television, Magazines}  
C. {Newspapers, Radio}  
D. {Newspapers, Magazines}

13.23 Consider Figure 4. The Snake River Company has a:
A. Weakly-dominant strategy.  
B. Non-strictly-dominant strategy.  
C. Strictly-dominated strategy.  
D. Iterated-weakly-dominated strategy.
13.24 Refer to Figure 5, which summarizes the monthly profits in thousands of dollars of the 7th Heaven and Rah-Rah convenience store chains, which are considering whether to open a franchise in downtown Pawtucket, or just off the interstate highway. Which convenience store chain has a strictly-dominant strategy?
A. Firm A
B. Firm B
C. Both firms
D. Neither firm

13.25 Refer to Figure 5, which summarizes the monthly profits in thousands of dollars of the 7th Heaven and Rah-Rah convenience store chains, which are considering whether to open a franchise in downtown Pawtucket, or just off the interstate highway. What is the solution profile for this game?
A. \{Pawtucket, Interstate\}
B. \{Interstate, Pawtucket\}
C. \{Pawtucket, Pawtucket\}
D. \{Interstate, Interstate\}

13.26 Suppose that Firm A and Firm B enter into a collusive agreement. Suppose Firm A violates the agreement, which results in Firm B deciding never again to cooperate with Firm A. This is an example of a:
A. Strictly-dominant strategy.
B. Trigger strategy.
C. Cheating rule.
D. Backward iteration.
E. Focal-point strategy.

13.27 A focal-point equilibrium:
A. May be a possible solution to a game involving multiple Nash equilibria.
B. Cannot exist in the presence of multiple Nash equilibria.
C. Results when two players follow a secure strategy.
D. Applies only to multistage games.

13.28 An extensive-form game summarizes:
A. Players, alternative strategies, order of moves, and payoffs.
B. Players, arrangements, situations, and payoffs.
C. Players, arrangements, order of moves, and payoffs.
D. Players, situations, alternative strategies, and payoffs.
E. Players, stages of the game, order of moves, and payoffs.
13.29 A solution to a multistage game may be arrived at through:
   A. Deductive reasoning.
   B. Inductive reasoning.
   C. Backward iteration.
   D. Simplex method.
   E. Maximin analysis.

13.30 A subgame perfect equilibrium:
   A. Is a Nash equilibrium to a multistage game.
   B. Is a solution to a subgame in a multistage game.
   C. Is a solution to any stage of a multistage game.
   D. Can only exist in the presence of multiple Nash equilibria.
   E. None of the above.

13.31 Consider Figure 6. This multistage game has how many subgames?
   A. 1
   B. 2
   C. 3
   D. 4
   E. 5

13.32 Consider Figure 6. The subgame perfect equilibrium for this game is:
   A. \{(1, (3, 2, 1))\}.
   B. \{(2, (1, 3, 2))\}.
   C. \{(2, (1, 1, 1))\}.
   D. \{(3, (3, 2, 2))\}.
   E. \{(3, (1, 2, 3))\}.
13.33 Consider Figure 6. The payoffs for the subgame perfect equilibrium of this game are:
A. \((100, 350)\).
B. \((225, 250)\).
C. \((150, 275)\).
D. \((250, 125)\).
E. \((250, 350)\).

13.34 Consider Figure 7. This multistage game has how many subgames?
A. 1
B. 2
C. 3
D. 4
E. 5

13.35 Consider Figure 7. The payoffs for the subgame perfect equilibrium for this game are:
A. \((3, 2)\).
B. \((1, 4)\).
C. \((3, 3)\).
D. \((1, 5)\).
E. \((4, 3)\).

13.36 Andrew wants to purchase Adam’s car. Andrew is prepared to pay a maximum of $2,000. Adam knows this. By contrast, Adam is not willing to accept anything lower than $1,000. Suppose Andrew makes the first offer, there are an even number offers and counteroffers, and Andrew and Adam are equally patient. Adam will sell his car for:
A. $1,000.
B. $1,500.
C. $2,000.
D. Somewhere between $1,000 and $2,000, but the exact amount cannot be determined without knowing Andrew’s and Adam’s opportunity cost per negotiating round.
E. Cannot be determined without first knowing the number of negotiating rounds.

13.37 Andrew wants to purchase Adam’s car. Andrew is prepared to pay a maximum of $2,000. Adam knows this. By contrast, Adam is not willing to accept anything lower than $1,000. Suppose Andrew makes the first offer, there are an odd number of offers and counteroffers, and Andrew and Adam are equally patient. Adam will sell his car for:
A. $1,000.
B. $1,500.
C. $2,000.
D. Somewhere between $1,000 and $2,000, but the exact amount cannot be determined without knowing Andrew’s and Adam’s opportunity cost per negotiating round.
E. Cannot be determined without first knowing the number of negotiating rounds.

13.38 Andrew wants to purchase Adam’s car. Andrew is prepared to pay a maximum of $2,000. Adam knows this. By contrast, Adam is not willing to accept anything lower than $1,000. Suppose Andrew makes the first offer, there are an even number of offers and counteroffers, and Andrew and Adam are equally patient. Andrew enjoys a negotiating advantage because he moves first.
A. Andrew enjoys a negotiating advantage because he moves first.
B. Adam enjoys a negotiating advantage because he is the seller.
C. Andrew enjoys a negotiating advantage because he makes the last counter offer.
D. Adam enjoys a negotiating advantage because he makes the last counter offer.
E. Andrew’s advantage increases with the number of negotiating rounds.

13.39 Andrew wants to purchase Adam’s car. Andrew is prepared to pay a maximum of $2,000. Adam knows this. By contrast, Adam is not willing to accept anything lower than $1,000. Because of the time value of money, suppose that any delay in reaching an agreement reduces Andrew’s and Adam’s gain from reaching an agreement by 10 percent. If Andrew makes the first offer, and there are a large, but even, number negotiating rounds, then Adam will sell his car for:
A. $1,000.
B. An amount somewhat greater than $1,500.
C. An amount somewhat less than $1,500.
D. $2,000.
E. None of the above since Andrew and Adam will be unable to negotiate a selling price.

13.40 Andrew wants to purchase Adam’s car. Andrew is prepared to pay a maximum of $2,000. Adam knows this. By contrast, Adam is not willing to accept anything lower than $1,000. Because of the time value of money, suppose that any delay in reaching an agreement reduces Andrew’s and Adam’s gain from reaching an agreement by 10 percent and 5 percent, respectively. If Andrew makes the first offer, and there are a very large number of negotiating rounds, then Adam will sell his car for approximately:
A. $750.
B. $1,000.
C. $1,300.
D. $1,700.
E. $2,100.

**SHORTEST PROBLEMS**

13.1 Suppose that Tsunami Corporation and Cyclone Company are equally-sized, dominant firms in the highly competitive spinnaker jetsam industry. Both firms are considering a change in their pricing policies. The following payoff matrix illustrates each firm’s annual profits in millions of dollars from any combination of pricing strategies.

<table>
<thead>
<tr>
<th>Cyclone</th>
<th>High Price</th>
<th>Low Price</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tsunami</strong></td>
<td>High Price</td>
<td>($6, $6)</td>
</tr>
<tr>
<td></td>
<td>Low Price</td>
<td>($8, $4)</td>
</tr>
</tbody>
</table>

Payoffs: (Tsunami, Cyclone)

A. Does either firm have a strictly-dominant strategy?
B. What strategy will each firm adopt?
C. Does this game have a Nash equilibrium?
13.2 Suppose that in the “Touchdown Game” discussed in the text the probabilities of either team winning the game from alternative offensive and defensive strategies are as follows.

<table>
<thead>
<tr>
<th>Baltimore Ravens</th>
<th>Pass</th>
<th>Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.Y. Giants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pass Defense</td>
<td>(65, 35)</td>
<td>(27, 73)</td>
</tr>
<tr>
<td>Run Defense</td>
<td>(74, 26)</td>
<td>(30, 70)</td>
</tr>
</tbody>
</table>

Payoffs: (N.Y. Giants, Baltimore Ravens)

A. Does either team have a strictly-dominant strategy?
B. What strategy will each team adopt?
C. Does this game have a Nash equilibrium?

13.3 The following payoff matrix represents another version of “Touchdown Game” where the entries in each cell indicate the probabilities of either team winning the game from alternative offensive and defensive strategies.

<table>
<thead>
<tr>
<th>Baltimore Ravens</th>
<th>Pass</th>
<th>Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.Y. Giants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pass Defense</td>
<td>(75, 20)</td>
<td>(40, 60)</td>
</tr>
<tr>
<td>Run Defense</td>
<td>(50, 50)</td>
<td>(45, 55)</td>
</tr>
</tbody>
</table>

Payoffs: (N.Y. Giants, Baltimore Ravens)

A. Does either team have a strictly-dominant strategy?
B. What strategy will each team adopt?
C. Does this game have a Nash equilibrium?
13.4 Fly-By-Night Airlines and Going-Going-Gone Airways are considering implementing a frequent-flyer program or continuing with their standard fare schedule. The following payoff matrix illustrates monthly profits in thousands of dollars for each air carrier.

\[
\begin{array}{c|c|c}
\text{Going-Going-Gone} & \text{Standard} & \text{Frequent-Flyer} \\
\hline
\text{Fly-By-Night} & \text{Standard} & ($250, $275) & ($210, $350) \\
 & \text{Frequent-Flyer} & ($325, $190) & ($200, $150) \\
\end{array}
\]

Payoffs: (Wing-and-a-Prayer Airlines, Fairways Airways)

A. Does either air carrier have a strictly-dominant strategy? Explain.
B. What is the strategy profile for this game?
C. Does this game have a Nash equilibrium?

LONGER PROBLEMS

13.1 Consider the following payoff matrix for a non-cooperative, simultaneous-move, one-shot game.

\[
\begin{array}{c|c|c|c}
\text{Player B} & \text{B1} & \text{B2} & \text{B3} \\
\hline
\text{A1} & (3, 3) & (4, 1) & (5, 4) \\
\text{A2} & (2, 2) & (3, 1) & (3, 3) \\
\text{A3} & (2, 2) & (3, 2) & (2, 4) \\
\end{array}
\]

Payoffs: (Player A, Player B)

A. Does either player have a strictly-dominant strategy?
B. What is the solution to this game?
C. Is this solution a Nash equilibrium?
D. Suppose that this is a multistage game and Player A moves first. Illustrate the extensive form of this game.
E. What are the subgames for this game?
F. What is the Nash equilibrium for each subgame?
G. Use backward induction to find the subgame perfect equilibrium. Illustrate your solution.
13.2 Consider the following payoff matrix for a non-cooperative, simultaneous-move, one-shot game.

```
Player B

<table>
<thead>
<tr>
<th></th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>(3, 3)</td>
<td>(4, 1)</td>
<td>(2, 4)</td>
</tr>
<tr>
<td>A2</td>
<td>(2, 3)</td>
<td>(3, 1)</td>
<td>(3, 2)</td>
</tr>
<tr>
<td>A3</td>
<td>(4, 4)</td>
<td>(3, 2)</td>
<td>(5, 2)</td>
</tr>
</tbody>
</table>
```

Payoffs: (Player A, Player B)

A. Does either player have a strictly-dominant strategy?
B. What is the solution to this game?
C. Is this solution a Nash equilibrium?
D. Suppose that this is a multistage game and Player A moves first. Illustrate the extensive form of this game.
E. What are the subgames for this game?
F. What is the Nash equilibrium for each subgame?
G. Use backward induction to find the subgame perfect equilibrium. Illustrate your solution.

13.3 Once again, suppose that Tsunami Corporation and Cyclone Company are equally-sized, dominant firms in the highly competitive spinnaker jetsam industry. Both firms are considering a change in their pricing policies. The following payoff matrix illustrates each firm’s annual profits in millions of dollars from any combination of pricing strategies.

```
Cyclone

<table>
<thead>
<tr>
<th></th>
<th>High Price</th>
<th>Low Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tsunami High Price</td>
<td>($6, $6)</td>
<td>($4, $8)</td>
</tr>
<tr>
<td>Low Price</td>
<td>($8, $4)</td>
<td>($5.5, $5.5)</td>
</tr>
</tbody>
</table>
```

Payoffs: (Tsunami, Cyclone)
A. Suppose that the firms’ annual profits may be reinvested at a compounded annual rate of 7 percent. Estimate the total economic benefit to Tsunami and Cyclone from a Nash equilibrium (no collusion) for an infinitely-repeated game?

B. What is the economic benefit to Tsunami and Cyclone from a collusive agreement?

C. What is the economic benefit to Tsunami or Cyclone from violating the agreement?

D. Based on your answers to parts A and B, is the collusive agreement stable, i.e., is the cartel likely to last?

13.4 Suppose that in the previous problem annual profits may be reinvested at a compounded annual rate of 25 percent.

A. Suppose that the firms’ annual profits may be reinvested at a compounded annual rate of 7 percent. Estimate the total economic benefit to Tsunami and Cyclone from a Nash equilibrium (no collusion) for an infinitely-repeated game?

B. What is the economic benefit to Tsunami and Cyclone from a collusive agreement?

C. What is the economic benefit to Tsunami or Cyclone from violating the agreement?

D. Based on your answers to parts A and B, is the collusive agreement stable, i.e., is the cartel likely to last?

13.5 Suppose that Andrew wants to purchase Adam’s car. Adam knows that Andrew is prepared to pay a maximum of $2,000. Adam is unwilling to accept anything lower than $1,000. If Andrew and Adam can come to an agreement, then the gain to both will add up to $1,000, which is the difference between the buyer’s and the seller’s reservation prices. Andrew’s and Adam’s discount rates per round are $\delta_A = 0.10$ and $\delta_B = 0.10$, respectively.

A. For a subgame-perfect equilibrium to exist, what portion of the surplus should Adam offer Andrew in the first round? What portion of the surplus should Adam keep for himself?

B. Suppose that Adam’s discount rate remains $\delta_B = 0.10$, and Andrew’s discount rate is $\delta_A = 0.20$. What portion of the surplus should Adam offer Andrew in the first round and what portion should he keep for himself?
ANSWERS TO MULTIPLE CHOICE QUESTIONS

13.1  A.
13.2  E.
13.3  C.
13.4  A.
13.5  C.
13.6  D.
13.7  B.
13.8  A.
13.9  E.
13.10 C.
13.11 E.
13.12 C.
13.13 A.
13.14 D.
13.15 D.
13.16 C.
13.17 D.
13.18 A.
13.19 D.
13.20 D.
13.21 B.
13.22 D.
13.23 A.
13.24 D.
13.25 C.
13.26 B.
13.27 A.
13.28 E.
13.29 C.
13.30 A.
13.31 C.
13.32 B.
13.33 B.
13.34 D.
13.35 A.
13.36 C.
13.37 A.
13.38 D.
13.39 B.
13.40 D.
13.1 A. Both firms have a strictly-dominant strategy. If Tsunami adopts a *High Price* strategy then it will be in Cyclone’s best interest to adopt a *Low Price* strategy. The reason for this is that a *Low Price* strategy will result in annual profits of $8 million, compared with $6 from a *High Price* strategy. Similarly, if Tsunami adopts a *Low Price* strategy, it will again be in Cyclone’s best interest to adopt a *Low Price* strategy since this will result in annual profit of $5.5 million, compared with $4 million from a *High Price* strategy. In other words, regardless of the strategy adopted by Tsunami, Cyclone’s strictly-dominant strategy is to charge a *Low Price*. Since the payoff matrix is symmetric, Tsunami also has a strictly-dominant strategy, which is to charge a *Low Price*.

B. The strictly-dominant strategy profile for this game is \{*Low Price*, *Low Price*\}.

C. The strategy profile for this game a Nash equilibrium since firm can improve its payoff by switching pricing strategies.

13.2 A. Both teams have a strictly-dominant strategy. If the Giants play *Pass Defense*, then the best strategy for the Ravens is to *Run* since this strategy offers the highest probability of winning. On the other hand if the Giants play a *Run Defense*, then the best strategy for the Ravens is, once again, to *Run*. From the Giants point of view, if the Ravens *Pass*, then the Giants should play a *Run Defense* because it offers the highest probability of winning. If the Ravens *Run*, then once again the Giants should play a *Run Defense*.

B. The strategy profile for this game is \{*Run Defense*, *Run*\}.

C. The strategy profile for this game a Nash equilibrium since neither coach can improve their payoff by switching strategies.

13.3 A. The Baltimore Raven have a dominant strategy, but the New York Giants do not. If the Giants play *Pass Defense*, then the best strategy for the Ravens is *Run* because it provides the highest probability winning. If the Giants play a *Run Defense*, then the Ravens should, once again, *Run*. From the Giants point of view, if the Ravens *Pass* then the Giants should play *Pass Defense*. But, if the Ravens *Run*, then the Giants should switch to a *Run Defense*.

B. The strategy profile for this game is \{*Run Defense*, *Run*\}. The reason for this is that the Ravens has a dominant strategy (*Run*) but the Giants do not. The Giants will select the strategy with the highest payoff given that the Ravens will *Run*, which is a *Run Defense*. 
C. The strategy profile for this game is a Nash equilibrium since neither coach can improve their payoff by switching strategies.

13.4 A. Neither firm has a strictly-dominant strategy. To see this, consider the problem from Fly-By-Nights perspective. If Going-Going-Gone stays with Standard fare schedule, then Fly-By-Night will adopt a Frequent-Flyer with a profit of $325, compared with a profit of $250 from its Standard fare schedule. If Going-Going-Gone adopts a Frequent-Flyer program, then Fly-By-Night will stick with its Standard fare schedule with a profit of $210, compared with a $200 profit from a Frequent-Flyer program. Thus, Fly-By-Night does not have a strictly-dominant strategy. Now, consider the problem from Going-Going-Gone’s perspective. If Fly-By-Night stays with its Standard strategy, then Going-Going-Gone will adopt a Frequent-Flyer program with a profit of $350, compared with a profit of $275 from its Standard fare schedule. If Fly-By-Night goes with a Frequent-Flyer program, then Going-Going-Gone will stay with its Standard fare schedule for a profit of $190, compared with a profit of $150 by adopting a Frequent-Flyer program.

B. If both air carriers are risk averse, then Fly-By-Night and Going-Going-Gone will employ a maximin strategy. If Fly-By-Night adopts a Standard strategy, then the worst that Going-Going-Gone can do is to adopt Standard strategy with a profit of $275. If the Fly-By-Night adopts a Frequent-Flyer strategy, then the worst that Going-Going-Gone can do is adopt a Frequent-Flyer program with a payoff of $150. Since a profit of $275 is the larger of the two worst payoffs, then the Going-Going-Gone’s maximin strategy is to stick with its Standard rate schedule. Now consider Fly-By-Night maximin strategy. If Going-Going-Gone adopts a Standard strategy, then Fly-By-Night can do no worse than adopt a Standard strategy with a payoff of $250. If Going-Going-Gone adopts a Frequent-Flyer strategy, then the worst that Fly-By-Night can do is to adopt a Frequent-Flyer strategy with a payoff of $200. Since $250 is the larger of the two worst payoffs, then Fly-By-Nights maximin strategy is stay with its Standard rate schedule. Thus, the strategy profile for this game is \{Standard, Standard\}.

C. The strategy profile \{Standard, Standard\} is not a Nash equilibrium since both firms can improve their payoffs by changing strategies.
13.1 A. Player A's strictly-dominant strategy is A1, i.e., regardless of the strategy adopted by Player B, A1 results in the largest payoff. By contrast, Player B's strictly-dominant strategy is B3, i.e., regardless of the strategy adopted by Player A, B3 results in the largest payoff.

B. The strictly-dominant strategy profile for this game is \{A1, B3\}.

C. The solution profile \{A1, B3\} is a Nash equilibrium. Neither player can improve his or her payoff by switching strategies.

D. The extensive form of this game is

E. This multistage game comprised of three subgames. The multistage game itself begins at the initial node, S1. The three subgames begin at subroots S2, S3, and S4. These subgames are highlighted by the dashed, rounded rectangles.

F. The Nash equilibria for subgames S2, S3, and S4 are \{A1, B3\}, \{A2, B3\}, and \{A3, B3\}.

G. Using the method of backward induction, the subgame perfect equilibrium for this game is \{A1, (B3, B3, B3)\}, which yields payoffs of 5 for Player A and 4 for Player B. This solution is illustrated in the following diagram:
13.2 A. The first thing to notice about this game is that regardless of the strategy chosen by Player A, Player B will never choose strategy $B2$. Moreover, regardless of the strategy chosen by Player B, Player A will never choose strategy $A2$. Thus, these strategies may be eliminated resulting in the following payoff matrix.

<table>
<thead>
<tr>
<th></th>
<th>$B1$</th>
<th>$B3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A1$</td>
<td>(3, 3)</td>
<td>(2, 4)</td>
</tr>
<tr>
<td>$A3$</td>
<td>(4, 4)</td>
<td>(5, 2)</td>
</tr>
</tbody>
</table>

Payoffs: (Player A, Player B)

An examination of the above matrix reveals that Player A’s a dominant strategy, which is $A3$. By contrast, Player B does not have a dominant strategy. If Player A chooses $A1$, then Player B will choose $B3$. If Player A chooses $A3$, then Player B will choose $A3$, then player B will choose $B1$.

B. Since Player B knows that Player A will choose $A3$, then Player B will choose strategy $B1$, which results in the largest payoff.

C. The solution profile for this game is $\{A3, B1\}$ is a Nash equilibrium since neither player’s payoff can be improved by switching strategies.

D. The extensive form of this game is

![Extensive Form Diagram]
E. This multistage game comprised of three subgames. The multistage game itself begins at the initial node, $S_1$. The three subgames begin at subroots $S_1$, $S_2$, and $S_3$. These subgames are highlighted by the dashed, rounded rectangles.

F. The Nash equilibria for subgames $S_2$, $S_3$, and $S_4$ are $\{A1, B3\}$, $\{A2, B1\}$, and $\{A3, B1\}$.

G. Using the method of backward induction, the subgame perfect equilibrium for this game is $\{A3,(B3,B1,B1)\}$, which yields payoffs of 4 for Player A and 4 for Player B. This solution is illustrated in the following diagram:

13.3 A. As we saw earlier, a Nash equilibrium occurs when both firms adopt a Low Price strategy. The economic benefit to both firms from following a Low Price strategy for an infinitely-repeated may game be calculated as the present value of an annuity (PVAD) for an infinite series of payments, i.e.,

$$PVAD_N = \frac{\pi_n(1 + i)}{i}$$

$$= \frac{5,500,000(1.07)}{0.07}$$

$$= 5,500,000(15.29)$$

$$= 84,071,428.57$$

where $\pi_n$ represents the profits to each firm from a Nash equilibrium.

B. Suppose that both firms illegally collude and adopt a High Price strategy. If both firm’s remain faithful to the agreement, then the economic benefit to both firms in an infinitely repeated game is

$$PVAD_H = \frac{\pi_H(1 + i)}{i}$$

$$= \frac{6,000,000(1.07)}{0.07}$$

$$= 6,000,000(15.29)$$

$$= 91,714,285.71$$

where $\pi_n$ represents the profits to each firm from remaining faithful (honest) to the collusive agreement.
C. Violating the collusive agreement by one firm will likely “trigger” a response by the other firm. In this case, the trigger strategy is not to engage in any future collusive arrangements. The economic benefit from violating the agreement is, therefore, the immediate (one-shot) gain from cheating ($\pi_c$) plus the present value of all future profits earned from the Nash equilibrium ($PVAD_N$).

$$\pi_c + PVAD_N = \pi_c + \pi_N(1 + \frac{1}{i})$$

$$= 6,000,000 + 84,071,428.57$$

$$= 90,071,428.57$$

D. Since $PVAD_H > \pi_c + PVAD_N$ ($91,714,285.71 > 90,071,428.57$) then there is no incentive to cheat. In other words, since the economic benefit to both firms by remaining “honest” to the agreement is greater than the economic benefit to either firm from cheating, then there is no incentive for either firm to cheat.

13.4 A. The economic benefit to both firms from following a Low Price strategy for an infinitely-repeated game is,

$$PVAD_N = \pi_N(1 + \frac{1}{i})$$

$$= 5,500,000(1.25)/0.25$$

$$= 5,500,000(5)$$

$$= 27,500,000$$

where $\pi_N$ represents the profits to each firm from a Nash equilibrium.

B. If both firms illegally collude by adopting a High Price strategy, then the economic benefit to both firms in an infinitely repeated game is

$$PVAD_H = \pi_H(1 + \frac{1}{i})$$

$$= 6,000,000(1.25)/0.25$$

$$= 6,000,000(5)$$

$$= 30,000,000$$

where $\pi_H$ represents the profits to each firm from remaining faithful (honest) to the collusive agreement.

C. Violating the collusive agreement by one firm will likely “trigger” a response by the other firm. In this case, the trigger strategy is not to engage in any future collusive arrangements. The economic benefit from violating the agreement is, therefore, the immediate (one-shot) gain from cheating ($\pi_c$) plus the present value of all future profits earned from the Nash equilibrium ($PVAD_N$).

$$\pi_c + PVAD_N = \pi_c + \pi_N(1 + \frac{1}{i})$$

$$= 6,000,000 + 27,500,000$$

$$= 33,500,000$$
D. Since $\pi_c + PVAD_n > PVAD_h$ ($33,500,000 > 31,000,000$), then there is an incentive to violate the agreement. In other words, the cartel is unstable and the collusive agreement is likely to break down.

13.5 A. $\theta_A = 1 - \delta_A = 0.90; \theta_B = 1 - \delta_B = 0.90$

\[ \omega_A = \theta_A(1 - \theta_B)/(1 - \theta_A\theta_B) \]
\[ = (0.90)(1 - 0.90)/(1 - 0.81) \]
\[ = 0.09/0.19 \]
\[ = 0.4737 \]

The amount of the surplus that Adam should offer Andrew is $\omega_A (\$1,000) = 0.4737(\$1,000) = \$473.68$

\[ \omega_B = (1 - \theta_A)/(1 - \theta_A\theta_B) \]
\[ = (1 - 0.90)/(1 - 0.81) \]
\[ = 0.10/0.19 \]
\[ = 0.5263 \]

The share of the surplus that Adam should keep is $\omega_B (\$1,000) = 0.5263(\$1,000) = \$526.32$

The sum of the shared surpluses is $\$1,000$.

B. $\theta_A = 1 - \delta_A = 0.80; \theta_B = 1 - \delta_B = 0.90$

\[ \omega_A = \theta_A(1 - \theta_B)/(1 - \theta_A\theta_B) \]
\[ = (0.80)(1 - 0.90)/(1 - 0.72) \]
\[ = 0.08/0.28 \]
\[ = 0.2857 \]

The amount of the surplus that Adam should offer Andrew is $0.2857(\$1,000) = \$285.71$

\[ \omega_B = (1 - \theta_A)/(1 - \theta_A\theta_B) \]
\[ = (1 - 0.80)/(1 - 0.72) \]
\[ = 0.20/0.28 \]
\[ = 0.7143 \]

The share of the surplus that Adam should keep is $\omega_B = 0.7143(\$1,000) = \$714.29$.

Once again, the sum of the shared surpluses is $\$1,000$. 

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