Lecture 8
Rivalry, Strategic Behavior and Game Theory
Overview

- Game Theory
- Simultaneous-move, nonrepeated interaction
- Sequential interactions
- Repeated strategic interactions
- Pricing coordination
Introduction

- So far we have used fairly static, simplistic models to study firms’ strategic interactions
- Want to begin developing tools that will allow us to analyze more complex interactions
  - When firms interact repeatedly over multiple period
- Leads to more realistic outcomes
To analyze manager’s strategic interactions in the market we use something called Game Theory.

One way economists use game theory is to address the question: “If I believe that my competitors are rational and act to maximize their own profits, how should I take their behavior into account when making my own profit-maximizing decisions?”
Game Theory

- Game Theory has been applied in a number of different areas by social scientists.
- Originally developed to analyze interactions of countries, with emphasis on the Cold War and Nuclear deterrence.
- Also used by Political Scientists to model the behavior of legislative bodies and why people vote.
Game Theory

Characteristics of Games

1. There are two or more players
   • Games with one player are boring.

2. Each player maximizes her utility, called a payoff
   • What we have been assuming all along.
Characteristics of Games

3. Each player knows the other players actions can affect her payoff.
   • No need to consider interactions if this is not true.

4. The other player’s interests are neither perfectly opposed nor perfectly coincident with those of a given player.
   • Must be some room for both gains from cooperation and competition.
There are two main type of games, Cooperative Games and Noncooperative Games.
Game Theory

- Noncooperative versus Cooperative Games
  - Cooperative Game
    - Players negotiate binding contracts that allow them to plan joint strategies
      - Example: Buyer and seller negotiating the price of a good or service or a joint venture by two firms (i.e. Microsoft and Apple)
      - Binding contracts are possible
Game Theory

Noncooperative versus Cooperative Games

- Noncooperative Game
  - Negotiation and enforcement of a binding contract are not possible
    - Example: Two competing firms take each other’s likely behavior into account when independently setting pricing and advertising strategy to gain market share
An example in game theory, called the *Prisoners’ Dilemma*, illustrates the problem oligopolistic firms face.
Competition Versus Collusion: The Prisoners’ Dilemma

Scenario

- Two prisoners have been accused of collaborating in a crime.
- They are in separate jail cells and cannot communicate.
- Each has been asked to confess to the crime.
# Payoff Matrix for Prisoners’ Dilemma

<table>
<thead>
<tr>
<th></th>
<th>Confess</th>
<th>Don’t confess</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prisoner A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confess</td>
<td>-5, -5</td>
<td>-1, -10</td>
</tr>
<tr>
<td>Don’t confess</td>
<td>-10, -1</td>
<td>-2, -2</td>
</tr>
</tbody>
</table>

Would you choose to confess?
Strategies

- Before figuring out what players will do we have to talk about their strategies.
- A firm’s strategy is based on understanding your opponent’s point of view, and (assuming you opponent is rational) deducing how he or she is likely to respond to your actions.
Some strategies work best when the other player makes certain moves. Other strategies work best regardless of what the other player does. Strategies that work best regardless of your opponents actions are called *dominant strategies*. 
Dominant Strategies

- Dominant Strategy
  - One that is optimal no matter what an opponent does.

- Back to Prisoner’s Dilemma game. Is there a dominant strategy here and if so, what is it?
Payoff Matrix for Prisoners’ Dilemma

Prisoner B

Confess | Don’t confess
---|---
Confess | -5, -5 | -1, -10
Don’t confess | -10, -1 | -2, -2

Would you choose to confess?
Let’s go over a second example.

- A & B sell competing products
- They are deciding whether to undertake advertising campaigns
Payoff Matrix for Advertising Game

Firm A

<table>
<thead>
<tr>
<th></th>
<th>Advertise</th>
<th>Don’t Advertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advertise</td>
<td>10, 5</td>
<td>15, 0</td>
</tr>
<tr>
<td>Don’t Advertise</td>
<td>6, 8</td>
<td>10, 2</td>
</tr>
</tbody>
</table>

Firm B
### Payoff Matrix for Advertising Game

#### Observations
- **A**: regardless of **B**, advertising is the best
- **B**: regardless of **A**, advertising is best

<table>
<thead>
<tr>
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<td><strong>Firm B</strong></td>
<td>6, 8</td>
<td>10, 2</td>
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</table>
### Payoff Matrix for Advertising Game

**Observations**
- Dominant strategy for A & B is to advertise
- Do not worry about the other player
- Equilibrium is dominant strategy

<table>
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<td><strong>Firm B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advertise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don’t Advertise</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Dominant Strategies

Game Without Dominant Strategy

– The optimal decision of a player without a dominant strategy will depend on what the other player does.
## Modified Advertising Game

<table>
<thead>
<tr>
<th></th>
<th>Firm B</th>
<th>Don’t Advertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advertise</td>
<td>10, 5</td>
<td>15, 0</td>
</tr>
<tr>
<td>Firm A</td>
<td>6, 8</td>
<td>20, 2</td>
</tr>
</tbody>
</table>

Note: The modified advertising game illustrates the strategic interaction between two firms, Firm A and Firm B. Each firm has two options: Advertise or Don’t Advertise. The payoffs are given in the form (Firm A, Firm B).
### Modified Advertising Game

#### Observations
- **A**: No dominant strategy; depends on **B**’s actions
- **B**: Advertise

#### Question
- What should **A** do? (Hint: consider **B**’s decision)

<table>
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<tr>
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<tr>
<td>Don’t Advertise</td>
<td>6, 8</td>
<td>20, 2</td>
</tr>
<tr>
<td><strong>Firm B</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Nash Equilibrium Revisited

- **Dominant Strategies**
  - “I’m doing the best I can no matter what you do.”
  - “You’re doing the best you can no matter what I do.”
The Nash Equilibrium Revisited

Nash Equilibrium

- “I’m doing the best I can given what you are doing”
- “You’re doing the best you can given what I am doing.”
Payoff Matrix for Pricing Game

<table>
<thead>
<tr>
<th>Firm 1</th>
<th>Charge $4</th>
<th>Charge $6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge $4</td>
<td>$12, $12</td>
<td>$20, $4</td>
</tr>
<tr>
<td>Charge $6</td>
<td>$4, $20</td>
<td>$16, $16</td>
</tr>
</tbody>
</table>
The Pricing Game

- Firm 1’s dominant strategy is to charge $4.
- Firm 2’s dominant strategy is to charge $4.
- Both firms will have higher profits if they could collude.
- Explicit and implicit collusion is possible.
- Once collusion exists, the profit motive to break and charge a lower price is significant.
Implications

- If a Nash equilibrium exists then it is self-enforcing—no firm has an incentive to deviate from the strategy
  - Can be multiple Nash equilibria

- Firms have an even strong incentive to choose a dominant strategy if one exists; in this situation you can be fairly certain how your rival will behave
Implications

➢ More likely to reach a Nash equilibrium when
  – Firms have experience in similar situations
  – Firms are better informed
  – There is a natural focal point
Implications of the Prisoners’ Dilemma for Oligopoly Pricing

Observations of Oligopoly Behavior

1) In some oligopoly markets, pricing behavior over time can create a predictable pricing environment and implicit collusion may occur.
Observations of Oligopoly Behavior

2) In other oligopoly markets, the firms are very aggressive and collusion is not possible.

• Firms are reluctant to change price because of the likely response of their competitors.
• In this case prices tend to be relatively rigid.
Implications of the Prisoners’ Dilemma for Oligopolistic Pricing

Price Signaling & Price Leadership

- Price Signaling
  - Implicit collusion in which a firm announces a price increase in the hope that other firms will follow suit
Implications of the Prisoners’ Dilemma for Oligopolistic Pricing

Price Signaling & Price Leadership

- Price Leadership
  - Pattern of pricing in which one firm regularly announces price changes that other firms then match
Implications of the Prisoners’ Dilemma for Oligopolistic Pricing

The Dominant Firm (Stackelberg) Model

- In some oligopolistic markets, one large firm has a major share of total sales, and a group of smaller firms supplies the remainder of the market.
- The large firm might then act as the dominant firm, setting a price that maximized its own profits.
Dominated Strategies

In more complicated games, sometimes you can eliminate strategies because they can be dominated by all other strategies.

Hilton and Hyatt are both considering building a hotel on an island.

Three possible choices, 70, 80, or 90 beds.
# Dominated Strategies

<table>
<thead>
<tr>
<th></th>
<th>Hilton</th>
<th>70 Beds</th>
<th>80 Beds</th>
<th>90 Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 Beds</td>
<td>$36, $36</td>
<td>$30, $40</td>
<td>$18, $36</td>
<td></td>
</tr>
<tr>
<td>80 Beds</td>
<td>$40, $30</td>
<td>$32, $32</td>
<td>$16, $24</td>
<td></td>
</tr>
<tr>
<td>90 Beds</td>
<td>$36, $18</td>
<td>$24, $16</td>
<td>$10, $10</td>
<td></td>
</tr>
</tbody>
</table>
Dominated Strategies

- Hyatt would never build a 90 bed hotel because they always get a higher payoff with the 80 bed hotel
- Hilton would never build a 90 bed hotel because they always get a higher payoff with a 80 bed hotel
- Once we eliminate this choice we are back to the simpler 2x2 matrix
Implications

- Managers often make decisions where the situation is not likely to be repeated or not repeated very often
  - Pricing a new product
  - Entering a new market
  - Acquiring another firm
Steps to follow in this situation

1. Estimate the payoff of each potential action, as well as the payoff of your rival
2. See if there are any weakly dominate strategies you can eliminate
3. Is there a dominant strategy? If yes, then take that action
4. If no, then estimate what your rival will do and identify your best action (which may be a mixed strategy)
Implications

Steps to follow in this situation

5. Check whether the outcome is a Nash equilibrium

6. Check whether the outcome is a Nash equilibrium—are you forecasting that your rival is behaving optimally? If no, then revise your forecast

Assume your rival is doing the same thing

– Put yourself in their desk
Implications

- If you are risk adverse or have little experience in this situation, may want to consider a *secure strategy*
  - Strategy that minimizes losses
  - Not the best strategy for the long-run
  - May be learning-by-doing
### Pricing Problem

<table>
<thead>
<tr>
<th>Firm 1</th>
<th>Firm 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Price</td>
<td>Low Price</td>
</tr>
<tr>
<td>10, 10</td>
<td>100, -50</td>
</tr>
<tr>
<td>High Price</td>
<td>-50, 100</td>
</tr>
</tbody>
</table>
Pricing Problem

- Non-repeated game
  - Strategy is Low$_1$, Low$_2$
- Repeated game
  - Tit-for-tat strategy is the most profitable

\[
\begin{array}{c|cc}
& \text{Low Price} & \text{High Price} \\
\hline
\text{Firm 1} & \begin{cases} 10, 10 \\ -50, 100 \end{cases} & \begin{cases} 100, -50 \\ 50, 50 \end{cases} \\
\text{Firm 2} & & \\
\end{array}
\]
Dynamic Price Competition

- Price competition can be viewed as a dynamic process
- Decisions by a firm today will affect its behavior as well as its competitors’ in the future
- Dynamic competition can also occur in non-price dimensions such as quality
Dynamic versus Static Models

- Dynamic models can address questions that static models cannot (Example: What determines the intensity of price competition?)
- What appears as short term profits (in a static model) are often followed by long term negative effects (in a dynamic model)
Dynamic Model Scenarios

- Static models cannot explain how firms can maintain prices above competitive levels without formal collusion.
- In other situations, even a small number of firms are sufficient to produce intense price competition.
- Dynamic models are useful in exploring such situations.
Tit-for-Tat Pricing

- When two firms compete over several periods, a tit-for-tat strategy may make cooperative pricing possible.
- Since each firm knows that its rival will match any price cut, neither has an incentive to engage in price cutting.
Tit-for-Tat Pricing with Many Firms

Condition for sustainable cooperative pricing

\[
\frac{1}{N} \left[ \Pi_M - \Pi_0 \right] \geq i - \frac{1}{N} \Pi_M
\]

\( N = \text{Number of firms} \quad \Pi_M = \text{Monopoly profit for the industry} \)

\( i = \text{Discount rate} \quad \Pi_0 = \text{Prevailing profit for the industry} \)
Tit-for-Tat Pricing with Many Firms

- The numerator is the annuity a firm will receive by cooperating.
- The denominator is the one time gain by not cooperating and inviting a tit-for-tat response from the rivals.
- When the condition is met, the present value of the annuity exceeds the one time gain from refusal to cooperate.
Coordination Problem

- While cooperative pricing is sustainable, the folk theorem does not rule out other equilibria.
- Achieving a desirable equilibrium out of many possible equilibria is a coordination problem.
- A cooperation inducing strategy that is also a compelling choice is a focal point.
Coordination in Practice

- Round number price points will help with coordination
- Even splits of the market (or status quo for market shares) is likely to be durable
- Coordination easier with fewer products that are identical
Coordination in Practice

- Conventions and traditions make rivals’ intentions transparent and help with coordination
- Examples: Standard cycles for adjusting prices, using standard price points for price quotes
Market Structure & Cooperative Pricing

- Achieving cooperative pricing may depend on certain market structure conditions

- Some examples are:
  - Concentration
  - Conditions that affect reaction speeds and detection lags
  - Asymmetries among firms
  - Price sensitivity of buyers
Relevant Structural Conditions

- Lumpiness of orders
- Information availability regarding sales transaction
- Volatility of demand conditions
Firms can facilitate cooperative pricing by

- Price leadership
- Advance announcement of price changes
- Most favored customer clauses
- Uniform delivered pricing
Cooperative Pricing

Conclusion

- Cooperation is difficult at best since these factors may change in the long-run.
Sequential Games

- Players move in turn
- Players must think through the possible actions and rational reactions of each player
Sequential Games

Examples

- Responding to a competitor’s ad campaign
- Entry decisions
- Responding to regulatory policy
Sequential Games

The Extensive Form of a Game

Scenario

- Two new (sweet, crispy) cereals
- Successful only if each firm produces one cereal
- Sweet will sell better
- Both still profitable with only one producer
Modified Product Choice Problem

Firm 1

<table>
<thead>
<tr>
<th></th>
<th>Crispy</th>
<th>Sweet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crispy</td>
<td>-5, -5</td>
<td>10, 20</td>
</tr>
<tr>
<td>Sweet</td>
<td>20, 10</td>
<td>-5, -5</td>
</tr>
</tbody>
</table>

Firm 2
Modified Product Choice Problem

Question
- What is the likely outcome if both make their decisions independently, simultaneously, and without knowledge of the other’s intentions?

<table>
<thead>
<tr>
<th>Firm 1</th>
<th>Firm 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crispy</td>
<td>-5, -5</td>
</tr>
<tr>
<td>Sweet</td>
<td>20, 10</td>
</tr>
<tr>
<td>Crispy</td>
<td>10, 20</td>
</tr>
<tr>
<td>Sweet</td>
<td>-5, -5</td>
</tr>
</tbody>
</table>
Assume that Firm 1 will introduce its new cereal first (a sequential game).

Question
- What will be the outcome of this game?
Sequential Games

The Extensive Form of a Game

- Using a decision tree
  - Work backward from the best outcome for Firm 1
Product Choice Game in Extensive Form

Firm 1
- Crispy
  - Firm 2
    - Crispy
      - -5, -5
    - Sweet
      - 10, 20
Firm 2
- Crispy
  - -5, -5
- Sweet
  - 20, 10
- Sweet
  - -5, -5
Sequential Games

➢ The Advantage of Moving First
  – In this product-choice game, there is a clear advantage to moving first.
Sequential Games

The Advantage of Moving First

➢ Assume: Duopoly

\[ P = 30 - Q \]

\[ Q = \text{Total Production} = Q_1 + Q_2 \]

\[ MC = 0 \]

\[ Q_1 + Q_2 = 10 \text{ and } P = 10 \quad \pi = 100 / \text{Firm} \]
Sequential Games

The Advantage of Moving First

➢ Duopoly

With Collusion

\[ Q_1 = Q_2 = 7.5 \text{ and } P = 15 \quad \pi = 112.50 / \text{Firm} \]

Firm 1 Moves First

\[ Q_1 = 15 \quad Q_2 = 7.5 \quad \text{and} \quad P = 7.50 \]

\[ \pi_1 = 112.50 \quad \pi_2 = 56.25 \]
## Choosing Output

<table>
<thead>
<tr>
<th>Firm 1</th>
<th>7.5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5</td>
<td>112.50, 112.50</td>
<td>93.75, 125</td>
<td>56.25, 112.50</td>
</tr>
<tr>
<td>10</td>
<td>125, 93.75</td>
<td>100, 100</td>
<td>50, 75</td>
</tr>
<tr>
<td>15</td>
<td>112.50, 56.25</td>
<td>75, 50</td>
<td>0, 0</td>
</tr>
</tbody>
</table>
Choosing Output

- This payoff matrix illustrates various outcomes
  - Move together, both produce 10
  - Question
    - What if Firm 1 moves first?

<table>
<thead>
<tr>
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<td>112.50, 56.25</td>
<td>75, 50</td>
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</table>
How To Make the First Move

- Demonstrate Commitment
- *Firm 1* must constrain his behavior to the extent *Firm 2* is convinced that he is committed
Threats, Commitments, and Credibility

Strategic Moves

- What actions can a firm take to gain advantage in the marketplace?
  - Deter entry
  - Induce competitors to reduce output, leave, raise price
  - Implicit agreements that benefit one firm
Empty Threats

- If a firm will be worse off if it charges a low price, the threat of a low price is not credible in the eyes of the competitors.
Question

- How did Wal-Mart become the largest retailer in the U.S. when many established retail chains were closing their doors?

  • Hint
    - How did Wal-Mart gain monopoly power?
    - Preemptive game with Nash equilibrium
### The Discount Store Preemption Game

**Company X**

<table>
<thead>
<tr>
<th></th>
<th>Enter</th>
<th>Don’t enter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter</td>
<td>-10, -10</td>
<td>20, 0</td>
</tr>
<tr>
<td>Don’t enter</td>
<td>0, 20</td>
<td>0, 0</td>
</tr>
</tbody>
</table>

**Wal-Mart**

<table>
<thead>
<tr>
<th>Enter</th>
<th>Don’t enter</th>
</tr>
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<tbody>
<tr>
<td>Enter</td>
<td>-10, -10</td>
</tr>
<tr>
<td>Don’t enter</td>
<td>0, 20</td>
</tr>
</tbody>
</table>
The Discount Store Preemption Game

- Two Nash equilibrium
  - Low left
  - Upper right

- Must be preemptive to win

<table>
<thead>
<tr>
<th></th>
<th>Enter</th>
<th>Don’t enter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wal-Mart</strong></td>
<td>-10, -10</td>
<td>20, 0</td>
</tr>
<tr>
<td><strong>Company X</strong></td>
<td>0, 20</td>
<td>0, 0</td>
</tr>
</tbody>
</table>

Must be preemptive to win.
Entry Deterrence

➢ To deter entry, the incumbent firm must convince any potential competitor that entry will be unprofitable.
First Mover Disadvantage

➢ There may be a disadvantage to being the first mover
  – Have to make the initial investment in developing a new product. Following firms can copy what you do and avoid the investment costs
  – Trying to set a standard
Flexibility and Options

- The value of commitments lies in creating inflexibility.
- However, when there is uncertainty, flexibility is valuable since future options are kept open.
- Commitments can sacrifice the value of the options.
Commitment-Flexibility Tradeoff

- By waiting, a firm preserves its option values
- By waiting, the firm also may allow its competitors to make preemptive investments
Preserving Flexibility

- Modify the commitment as conditions evolve
- Delay commitment until better information is available on profitability
- Make unprofitable commitments today to preserve valuable options in the future
Flexibility and Real Options

- A real option exists if future information can be used to tailor decisions
- Better information about demand can be utilized by delaying implementation of projects
- Value of real options may be limited by the risk of preemption
- Key managerial skill in spotting valuable real options
Implications

- When operating in a sequential environment managers should
  1. Carefully define the sequence of moves
  2. Work backwards from the end to predict the likely outcome of the interactions, making sure you assume your rival is acting optimally
  3. Decide whether there is any credible commitment you can make to change your rivals prediction of your action
What Game Theory Can Teach Managers

- Understand your business setting
  - Identify your rivals and how you interact

- Place yourself behind your rivals’ desk
  - Consider the entire sequence of decisions
  - Start at the end and work backwards to determine your best strategy, as well as your rivals’ best strategy

- With a first mover advantage try and move first
What Game Theory Can Teach Managers

- With a first mover advantage try and move first
  - If you can’t move first, decide if there are credible steps you can take to induce your rivals to change their decisions and improve your outcome

- With a second mover advantage, avoid moving first
  - Be unpredictable and maximize flexibility

- Repetition facilitates cooperation
Summary

- A game is cooperative if the players can communicate and arrange binding contracts; otherwise it is noncooperative.

- A Nash equilibrium is a set of strategies such that all players are doing their best, given the strategies of the other players.
Summary

- Strategies that are not optimal for a one-shot game may be optimal for a repeated game.

- Strategies such as tit-for-tat pricing can facilitate coordination but are difficult to implement.

- Market structure affects the sustainability of cooperative pricing.
Summary

- An empty threat is a threat that one would have no incentive to carry out.

- To deter entry, an incumbent firm must convince any potential competitor that entry will be unprofitable.