Chapter 13

GAME THEORY AND COMPETITIVE STRATEGY
Topic to be Discussed

- Gaming and Strategic Decisions
- Dominant Strategies
- The Nash Equilibrium Revisited
- Repeated Games
- Sequential Games
Gaming and Strategic Decisions

- **Game** is any situation in which *players* (the participants) make strategic decisions.
- Strategic decisions result in *payoffs* to the players: outcomes that generate rewards or benefits.
Game theory tries to determine optimal strategy for each player.

- **Strategy** is a rule or plan of action for playing the game.
- **Optimal strategy** for a player is one that maximizes the expected payoff.

We consider players who are rational – they think through their actions.
Noncooperative versus Cooperative Games

- **Cooperative Game**
  - Players negotiate binding contracts that allow them to plan joint strategies
  - Binding contracts are possible

- **Noncooperative Game**
  - Negotiation and enforcement of binding contracts between players is not possible
  - Binding contracts are not possible
Noncooperative versus Cooperative Games

- An Example: How to buy a dollar bill
  1. Auction a dollar bill
  2. Highest bidder receives the dollar in return for the amount bid
  3. Second highest bidder must pay the amount he or she bid but gets nothing in return
  4. How much would you bid for a dollar?
- Typically bid more for the dollar when faced with loss as second highest bidder
Dominant Strategy

- Dominant Strategy is one that is optimal no matter what an opponent does.
- Observations
  - A: regardless of B, advertising is the best
  - B: regardless of A, advertising is best

<table>
<thead>
<tr>
<th>Firm A</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>
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</tbody>
</table>
Observations

- Dominant strategy for A and B is to advertise
- Do not worry about the other player
- Equilibrium in dominant strategy

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<td>6, 8</td>
</tr>
<tr>
<td><strong>Firm B</strong></td>
<td>15, 0</td>
<td>10, 2</td>
</tr>
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Equilibrium in dominant strategies

- Outcome of a game in which each firm is doing the best it can regardless of what its competitors are doing
- Optimal strategy is determined without worrying about the actions of other players

However, not every game has a dominant strategy for each player
Game Without Dominant Strategy

- The optimal decision of a player without a dominant strategy will depend on what the other player does.
- Revising the payoff matrix, we can see a situation where no dominant strategy exists.
Observations

- **A:** No dominant strategy; depends on B’s actions
- **B:** Dominant strategy is to advertise
- **Firm A** determines B’s dominant strategy and makes its decision accordingly

<table>
<thead>
<tr>
<th></th>
<th><strong>Firm B</strong></th>
<th><strong>Firm A</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Advertise</strong></td>
<td>10, 5</td>
<td>15, 0</td>
</tr>
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<td>20, 2</td>
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The Nash Equilibrium Revisited

- **Nash Equilibrium**: A set of strategies (or actions) such that each player is doing the best it can given the actions of its opponents.
- None of the players have incentive to deviate from its Nash strategy, therefore it is stable.
- Dominant strategy is a special case of Nash equilibrium.
The Nash Equilibrium Revisited

- Two cereal companies face a market in which two new types of cereal can be successfully introduced, provided each type is introduced by only one firm.
- Product Choice Problem:
  - Market for one producer of crispy cereal
  - Market for one producer of sweet cereal
  - Each firm only has the resources to introduce one cereal
  - Noncooperative
Product Choice Problem

- If Firm 1 hears Firm 2 is introducing a new sweet cereal, its best action is to make crispy.
- Bottom left corner is Nash equilibrium.
- What is other Nash Equilibrium?

<table>
<thead>
<tr>
<th></th>
<th>firm 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crispy</td>
<td>-5, -5</td>
</tr>
<tr>
<td>Sweet</td>
<td>10, 10</td>
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</tbody>
</table>
Beach Location Game

- Scenario
  - Two competitors, Y and C, selling soft drinks
  - Beach is 200 yards long
  - Sunbathers are spread evenly along the beach
  - Price Y = Price C
  - Customer will buy from the closest vendor
Where will the competitors locate (i.e., where is the Nash equilibrium)?

- Will want to all locate in center of beach
Maximin strategies

- Observations
  - Dominant strategy
    - Firm 2: Invest
  - Firm 1 should expect Firm 2 to invest
  - Nash equilibrium
    - Firm 1: invest
    - Firm 2: Invest
  - This assumes Firm 2 understands the game and is rational

<table>
<thead>
<tr>
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<th>Firm 2</th>
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<tbody>
<tr>
<td></td>
<td>Don’t invest</td>
</tr>
<tr>
<td>Firm 1</td>
<td></td>
</tr>
<tr>
<td>Don’t invest</td>
<td>0, 0</td>
</tr>
<tr>
<td>Invest</td>
<td>-100, 0</td>
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</tbody>
</table>
Maximin strategies

- Observations
  - If Firm 2 does not invest, Firm 1 incurs significant losses
  - Firm 1 might play don’t invest
    - Minimize losses to 10 – maximin strategy
Maximin strategies

- If both are rational and informed
  - Both firms invest
  - Nash equilibrium

- If Player 2 is not rational or completely informed
  - Firm 1’s maximin strategy is to not invest
  - Firm 2’s maximin strategy is to invest
  - If 1 knows 2 is using a maximin strategy, 1 would invest
Maximin strategies

- If Firm 1 is unsure about what Firm 2 will do, it can assign probabilities to each possible action.
  - Could use a strategy that maximizes its expected payoff.
  - Firm 1’s strategy depends critically on its assessment of probabilities for Firm 2.
Prisoners’ Dilemma

- What is the:
  - Dominant strategy
  - Nash equilibrium
  - Maximin solution
- Dominant strategies are also maximin strategies
- Both confess is both Nash equilibrium and maximin solution

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<thead>
<tr>
<th></th>
<th>Confess</th>
<th>Don’t Confess</th>
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</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>
<tr>
<td><strong>Prisoner B</strong></td>
<td></td>
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Chapter 13
Mixed Strategy

- Pure Strategy
  - Player makes a specific choice or takes a specific action

- Mixed Strategy
  - Player makes a random choice among two or more possible actions, based on a set of chosen probabilities
Matching Pennies

- Pure strategy: No Nash equilibrium
  - No combination of head and tails leaves both players better off
- Mixed strategy:
  Random choice is a Nash equilibrium

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<thead>
<tr>
<th></th>
<th>Heads</th>
<th>Tails</th>
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<tr>
<td>Heads</td>
<td>1, -1</td>
<td>-1, 1</td>
</tr>
<tr>
<td>Tails</td>
<td>-1, 1</td>
<td>1, -1</td>
</tr>
</tbody>
</table>
Matching Pennies

- Player A might flip coin playing heads with $\frac{1}{2}$ probability and tails with $\frac{1}{2}$ probability.
- If both players follow this strategy, there is a Nash equilibrium – both players will be doing the best they can given what their opponent is doing.
- Although the outcome is random, the expected payoff is 0 for each player.
One reason to consider mixed strategies is when there is a game that does not have any Nash equilibriums in pure strategy.

When allowing for mixed strategies, every game has a Nash equilibrium.

Mixed strategies are popular for games like poker.

A firm might not find it reasonable.
# The Battle of Sexes

- **Pure Strategy**
  - Both watch wrestling
  - Both watch opera

- **Mixed Strategy**
  - Jim chooses wrestling
  - Joan chooses wrestling

<table>
<thead>
<tr>
<th></th>
<th>Wrestling</th>
<th>Opera</th>
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</thead>
<tbody>
<tr>
<td><strong>Jim</strong></td>
<td>2,1</td>
<td>0,0</td>
</tr>
<tr>
<td><strong>Joan</strong></td>
<td>0,0</td>
<td>1,2</td>
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</table>
Repeated Games

- Game in which actions are taken and payoffs are received over and over again
- With each repetition of the Prisoners’ Dilemma, firms can develop reputations about their behavior and study the behavior of their competitors
### Pricing Problem

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

- How does a firm find a strategy that would work best on average against all or almost all other strategies?
- Tit-for-tat strategy
  - Repeated game strategy in which a player responds in kind to an opponent’s previous play, cooperating with cooperative opponents and retaliating against uncooperative ones.
Tit-for-Tat Strategy

- What if the game is infinitely repeated?
  - Competitors repeatedly set price every month, forever
  - Tit-for-tat strategy is rational
    - If competitor charges low price and undercuts firm
    - Will get high profits that month but know I will lower price next month
    - Both of us will get lower profits if keep undercutting, so not rational to undercut
Tit-for-Tat Strategy

- What if repeated a finite number of times?
  - If both firms are rational, they will charge high prices until the last month
  - After the last month, there is no retaliation possible
  - But in the month before last month, knowing that will charge low price in last month, will charge low price in month before
  - Keep going and see that only rational outcome is for both firms to charge low price every month
Tit-for-Tat Strategy

- If firms don’t believe their competitors are rational or think perhaps they aren’t, cooperative behavior is a good strategy.
- Most managers don’t know how long they will be competing with their rivals.
- In a repeated game, prisoner’s dilemma can have cooperative outcome.
Repeated Games

○ Conclusion
  • Cooperation is difficult at best since these factors may change in the long run
  • Need a small number of firms
  • Need stable demand and cost conditions
    ○ This could lead to price wars if don’t have them
Oligopolistic Cooperation in the Water Meter Industry

- Characteristics of the Market
  - Four producers of water meters
    - Rockwell International
    - Badger Meter
    - Neptune Water Meter Company
    - Hersey Products
    - Rockwell has about 35% of market share
    - Badger, Neptune, and Hersey combined have about a 50 to 55% share
Oligopolistic Cooperation in the Water Meter Industry

- Most buyers are municipal water utilities
- Very inelastic demand
  - Not a significant part of the budget for providing water
- Demand is stable
  - Demand grows steadily with population
- Utilities have long-standing relationships with suppliers
  - Reluctant to switch
Oligopolistic Cooperation in the Water Meter Industry

- Significant economies of scale
- Both long term relationship and economies of scale represent barriers to entry
  - Hard for new firms to enter market
- If firms were to cooperate, could earn significant monopoly profits
- If compete aggressively to gain market share, profits will fall to competitive levels
Oligopolistic Cooperation in the Water Meter Industry

- This is a Prisoners’ Dilemma – what should the firms do?
  - Lower price to a competitive level
  - Cooperate
- Companies have been playing repeated game for decades
- Cooperation has prevailed given market characteristics
Sequential Games

- Players move in turn, responding to each other’s actions and reactions
  - Ex: Stackelberg model (ch. 12)
  - Responding to a competitor’s ad campaign
  - Entry decisions
  - Responding to regulatory policy
Going back to the product choice problem

- 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

- If firms both announce their decisions independently and simultaneously, they will both pick sweet cereal and both will lose money.
- What if Firm 1 sped up production and introduced new cereal first?
  - Now there is a sequential game
  - Firm 1 will think about what Firm 2 will do
Extensive Form of a Game

- Extensive Form of a Game
  - Representation of possible moves in a game in the form of a decision tree
    - Allows one to work backward from the best outcome for Firm 1
Product Choice Game in Extensive Form

Firm 1
  ──── Crispy ──── Firm 2
  │              │
  │              │
  │              │
Sweet   Firm 2
  │              │
  │              │
  │              │
Crispy   Firm 2
  │              │
  │              │
  │              │
Sweet

Payoffs:
- Crispy, Crispy: -5, -5
- Crispy, Sweet: 10, 20
- Sweet, Crispy: 20, 10
- Sweet, Sweet: -5, -5