Lecture 21: Strategic Interaction and Game Theory

Clicker Question
Strategic Interaction

- In perfectly competitive markets (like the market for corn), firms do not compete with other firms on an individual basis.
  - If Farmer Jane grows corn, she couldn’t care less about what Farmer Jones is doing.
  - Farmer Jane looks up the price of corn in the newspaper or online,…
  - and she bases her business strategy on the price.
  - Farmer Jane does **NOT interact strategically** with her competitors.

- Monopolies, too, have **NO strategic interaction** with competitors (unless there are potential entrants, they have no competitors 😊).

- But suppose two fancy hotels are located across the street from one another (a duopoly).
  - The owner of each hotel will be concerned about the **pricing** strategy of the other owner,…
  - and about the other’s business strategy in general.
  - Each owner will base her own business strategy…
  - …on her beliefs about the strategy of her competitor.
  - This is an example of **strategic interaction**.
Strategic interaction is very important when a small number of people or firms engage in *bargaining, conflict* or *competition*.

- Duopoly (two competing firms)
- Oligopoly (several competing firms)
- Contracts
- Legal Disputes
- Political campaigns

**Clicker Question**
Game Theory

- **Game Theory** refers to a set of mathematical tools used to analyze strategic interaction.
  
  - Game theory is often applied in economics, political science, and military science,…
  
  - but game theory is *not* commonly applied to ordinary games like chess or tennis (at least not yet 😃).

- In game theory,
  
  - *players* (decision makers)…
  
  - adopt *strategies* (complete plans of action)…
  
  - and receive *payoffs* (rewards or punishments), which depend on the strategies of all of the players.

- There must be at least two players in a game, but games with any number of players can be analyzed.

Strategies

- A *strategy* is a **complete plan** that describes the *action* a player will take *in every circumstance* that she can observe.
  
  - Sometimes, a strategy will involve only one action:
    
    (“I'll ask my boss for a raise [salary increase].”)

  
  - But some strategies are complex plans that involve many possible actions (*e.g. military strategies*).
Coordination in Business

- Sometimes firms can increase profits by coordinating their strategies.

**Example:** If a men’s clothing shop and a women’s clothing shop locate in the same mall, both may attract more customers.

**Example:** If two similar hardware stores locate further apart, they can charge higher prices, because they won’t have to compete with each other.

- There are many other examples where firms can increase profits by coordinating.
  - One firm supplies inputs to another firm *precisely when they are needed*.
  - All firms in a shopping center stay open during the *same hours*. [Why?]
  - All car thieves steal cars on the *same day*, so that police are spread thin.
  - Firms put their trucks on the road at *different times*, in order to avoid congestion.
Battle of the Sexes

- The **Battle of the Sexes** is a game-theory model of coordination in business (or in personal relationships).
- To keep the game simple, only two players are modeled.
- Vanesa wants to go to a football match *F*, but Miguel wants to go to the opera *R*.
- If they both do *F*, then Vanesa gets payoff 2, and Miguel gets 1,
- and if they both do *R*, then Vanesa gets 1 and Miguel gets 2.
- But if they do different things, then both get 0.
- Each must buy his/her ticket without knowing what the other is doing. [*Miguel forgot to charge his cell phone.*]

<table>
<thead>
<tr>
<th></th>
<th>Miguel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>F</em></td>
</tr>
<tr>
<td><em>F</em></td>
<td>1</td>
</tr>
<tr>
<td><em>R</em></td>
<td>0</td>
</tr>
</tbody>
</table>

The **Battle of the Sexes** is a game-theory model of coordination in business (or in personal relationships).

Game-Theorey Terminology

- Vanesa and Miguel are players.
- *F* and *R* are strategies.
- \{*F*, *R*\} is the strategy space (the set of allowable strategies).
- 2, 1 and 0 are payoffs.
- Each cell in the table corresponds to a strategy profile (one strategy for each player), and the contents of the cell are the payoffs corresponding to that profile.
  - For example, the top-right cell represents the strategy profile \(\langle F, R \rangle\) (Vanesa chooses *F*; Miguel chooses *R*).
  - 0 for Vanesa and 0 for Miguel are the corresponding payoffs.
The Battle of the Sexes is modeled as a normal-form game.
- Each row represents a strategy for one player (Vanesa),…
- Each column represents a strategy for the other player (Miguel).
- The row player chooses up or down;
- the column player chooses left or right.

In textbooks, the game is usually illustrated in black and white,…
- with the first number inside each cell representing the payoff to the row player,
- and the second to the column player.

Applying Game Theory

Can we use game theory to predict the outcomes of strategic interaction?

What strategies should we expect Vanesa and Miguel to adopt in their “battle of the sexes”?

Unfortunately, game theory has a number of different “solution concepts” that sometimes predict different outcomes.

The most commonly used solution concept is the Nash equilibrium, named after the mathematician John Nash [Nobel Prize, 1994].
- Sometimes we call it simply “an equilibrium.”
Nash Equilibrium

A **Nash equilibrium** is a strategy profile in which each player has chosen the strategy that is a **best response** to the strategies of the other players.

Equivalently, in a Nash equilibrium, if all players found out what the others were going to do,…

…*no* player would want to **deviate** [change] from her chosen strategy.

Does the word “equilibrium” make sense for this this situation? Why?

Equilibrium in the Battle of the Sexes

What is Vanesa’s best response if

- Miguel chooses **F**?
  - Answer: Vanesa chooses **F** and gets 2 instead of 0.
- Miguel chooses **R**
  - Answer: Vanesa chooses **R** and gets 1 instead of 0.

What is Miguel’s best response if

- Vanesa chooses **F**?
  - Answer: ??
- Vanesa chooses **R**?
  - Answer: ??

Result: the strategy profiles \( <F, F> \) and \( __, __ \) are Nash equilibria (best responses for each player to the other’s strategy—two circles).
Another Method of Finding Equilibria

Suppose both Vanesa and Miguel decide to go to the football match.

- Is that an equilibrium?
- Given that Miguel has chosen \( F \), what happens to Vanesa if she deviates from \( F \) to \( R \)?
  - Answer: ?
  - So ___ is Vanesa’s best response to Miguel’s \( F \).
- Given that Vanesa has chosen \( F \), what happens to Miguel if he deviates from \( F \) to \( R \)?
  - Answer: ??
  - So ___ is Miguel’s best response to Vanesa’s \( F \).
- Result: the strategy profile \( \langle F, F \rangle \) IS an equilibrium!
- Likewise, \( \langle R, R \rangle \) is an equilibrium.

Suppose Vanesa goes to football and Miguel goes to the opera \( \langle F, R \rangle \).

- Is \( \langle F, R \rangle \) an equilibrium?
- Given that Miguel has chosen \( R \), what happens to Vanesa if she deviates from \( F \) to \( R \)?
  - Answer: she would get 1 instead of 0, so she would deviate.
  - \( F \) is not Vanesa’s best response to Miguel’s \( R \).
- Therefore \( \langle F, R \rangle \) is not an equilibrium!
- We do not have to ask if Miguel would also deviate.

Likewise, \( \langle R, F \rangle \) is not an equilibrium.
In the “Battle of the Sexes” coordination failure is not an equilibrium!

Miguel would have to do what Vanesa wants, or *vice versa*.

Both of these equilibria are called **pure-strategy** equilibria, because neither player chooses his strategy randomly.

There is a **mixed-strategy** equilibrium also: Vanesa goes to football with probability \(\frac{2}{3}\) and to the opera with probability \(\frac{1}{3}\). Miguel does the opposite. *[You are not required to know this.]*

*Extra credit: prove that this is an equilibrium 😊!*
The Fiat-Money Game

Acceptance of fiat money is also a coordination game.

If *Ma* and *Huang* both accept dollars (*A*) in exchange for goods, then both benefit from voluntary exchange.

But if *Ma* accepts dollars (*A*) and *Huang* rejects them (*R*), then *Ma* loses.

- He sells his goods, but he cannot buy anything with the money he receives.

If both *Ma* and *Huang* reject the dollar, then neither benefits from voluntary exchange, but neither loses anything either.

Acceptance of fiat money is also a coordination game.

---

**Clicker Question**
Cooperation versus Competition

- Sometimes cooperation is more profitable or productive than competition.

- But cooperation can be hard to maintain.

- If all other firms (or players) are cooperating, it may be profitable for an individual firm to “defect” or cheat.

Example: Coke and Pepsi could each earn more if they could both spend less on advertising.

Example: The U.S. and Russia would both be better off if they could commit to keeping fewer nuclear weapons.

The game-theory model of cooperation vs. competition is called the “Prisoners’ Dilemma”
Thelma and Louise have been caught by the police.

- Police have evidence to put them behind bars for 5 years each,…
- but with a confession, the police could get 20-year sentences.

So the police offer them the following terms:
- If only one person confesses, she will get only 2 years in prison, but the other gets 20 years,
- …but if both confess, each gets 15 year in prison.

Thelma and Louise each has two possible strategies:
- Silence (S) [Try to cooperate with the other player.]
- Confession (C) [Follow narrow self-interest.]

Each has to make her choice without knowing what the other will do.

---

Equilibrium in the Prisoners’ Dilemma

Suppose both Thelma and Louise decide to stay silent (S).

- Is that an equilibrium?

Given that Louise has chosen S, what happens to Thelma if she deviates from S to C?

- Answer: she would get -2 instead of -5.
- Therefore, \( \langle S, S \rangle \) IS NOT an equilibrium!

Is \( \langle C, S \rangle \) an equilibrium?

Louise would get -15 instead of -20 if she deviated to C, so \( \langle C, S \rangle \) is NOT an equilibrium.

Similarly, \( \langle S, C \rangle \) is NOT an equilibrium.
Is \( \langle C, C \rangle \) an equilibrium?

- Given that Louise has chosen \( C \), will Thelma prefer to play \( C \) too?
  - Yes, she will lose more from deviating to \( S \)
  - So \( C \) is Thelma’s best response to Louise’s \( C \)
- Given that Thelma has chosen to play \( C \), Louise’s best response is to play \( C \) as well.

\( \langle C, C \rangle \) is an equilibrium—the only equilibrium, even though both would be better off if they could commit to silence \( S \)!

\[ \langle S, S \rangle \text{ Pareto dominates } \langle C, C \rangle. \]

For each player, confession \( C \) is a strictly dominant strategy—i.e. it is better to play \( C \), no matter what the other person does.

For each player, \( S \) is a strictly dominated strategy—i.e. another strategy is better than \( S \) no matter what the other person may do.

---

**Example:** Prisoners Dilemma--OPEC

- OPEC is an organization of petroleum-producing countries that promise to cooperate.
- OPEC sets production limits for each member country, which pushes up the petroleum price.
- But a number of countries cheat and produce more petroleum than OPEC rules allow.
- Some analysts believe that OPEC is completely ineffective…
- and the price of petroleum ends up at the competitive price.
Cooperation and the Prisoners’ Dilemma

The prisoners dilemma illustrates how difficult it is for competing firms to cooperate with each other, even when cooperating is Pareto efficient.

Whatever they have agreed to, each player can do better by cheating (following narrow self-interest).

That is why OPEC countries cheat and overproduce.

That is why firms and political candidates employ negative advertising.

Too bad (for them) that they cannot make a binding commitment.

Clicker Question
End of File