Lecture 21: Strategic Interaction and Game Theory

Office Hours This Friday: 11-12 only, not 10-11.

An additional hour will be added for Friday afternoon and announced online.

Reminders: Graded Homework due Monday at 7pm. No lectures, discussion sections or office hours next week.

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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.

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- 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**.

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- 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

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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.
- 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.

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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).

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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.

- 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.

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n Q

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.]

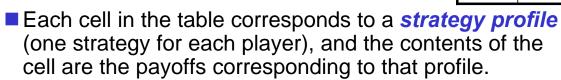
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Game-Theory Terminology

■ 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.



- For example, the top-right cell represents the strategy profile (F, R) (Vanesa chooses F; Miguel chooses R).
- 0 for Vanesa and 0 for Miguel are the corresponding payoffs.

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Miguel

0

2

Miguel

- 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,...
- Miguel
 F R

 ESP 2, 1 0, 0

 0, 0 1, 2

0

- with the first number inside each cell representing the payoff to the row player,
- and the second to the column player.

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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."

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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?

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Equilibrium in the Battle of the Sexes

- 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: she would get 0 instead of 2.
 - ♦ So **F** 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: he would get 0 instead of 1.
 - ♦ So **F** is Miguel's best response to Vanesa's **F**.
 - Result: the strategy profile (F, F) IS an equilibrium!
 - Likewise, (R, R) is an equilibrium.

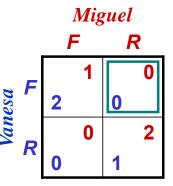
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Miguel

0

2

- Suppose Vanesa goes to football and Miguel goes to the opera (F, R).
 - Is (F, R) 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 (F, R) is not an equilibrium!
 - •We do not have to ask if Miguel would also deviate.
- Likewise, (R, F) 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 2/3 and to the opera with probability 1/3. Miguel does the opposite. [You are not required to know this.]
 - Extra credit: prove that this is an equilibrium !

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Clicker Question

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 *Ma 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.

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Clicker Question

Huang

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.

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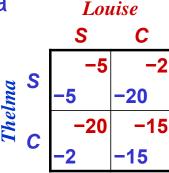
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- **Example:** Coke and Pepsi could each earn more if they could both spend less on advertising.
- **Example:** The U.S. and Russia would both be better off if they could commit to keeping fewer nuclear weapons.

■The game-theory model of cooperation vs. competition is called the "*Prisoners' Dilemma*"

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.

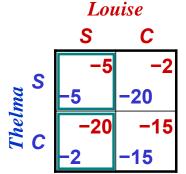
EC101 DD & EE / Manove | Strategic Interaction>Prisoners' Dilemma

Equilibrium in the Prisoners' Dilemma

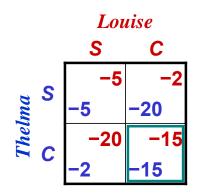
- Suppose both Thelma and Louise decide to stay silent (S).
 - Is that an equilibrium?
 - Given that Louise has chosen S. what happens to Thelma if she deviates from S to C?
 - Therefore, (S, S) IS NOT an equilibrium!



- Is (C, S) an equilibrium?
 - Louise would get −15 instead of −20 if she deviated to C, so it is NOT.
 - Similarly, (S, C) is NOT an equilibrium.



- Is (C, C) 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.



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

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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.

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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.



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