Lecture 4: Game Theory, Social Interaction, and Dilemmas

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Key Phrases

- Lec link https://drive.google.com/file/d/1roz6yqm78tmROmt6Wb9fZOYw_4LXvsoe/view?usp=sharing
- Optimal Decision in Social Interaction
  - driving example
  - can self-interest also promote wellbeing?
- Tragedy of the commons
- Simultaneous Games
- Sequential Movers Game
- Dominant Strategy/Best Response
  - Dominant Strategy Equlibrium
- Nash Equlibrium
- The prisoners dilemma
  - Free riding
- Prisoners dilemma and Public Goods
- Ultimatum game

Part 1. Social Interaction

- In Lecture 3 we went through how Maya decides on how many hours she wants to spend studying. Note that Maya was the sole participant in this decision making criteria, and according to the set up noone else affected her choice and her decision and she did not affect anyone else's decision.
- But to conceptualize such autonomous decision making case is mostly impractical due to social interaction.
- In many situations your decision is not only influenced by your choice but also other people's choice.
- Let's go over a classic example of driving. In the US, France or South Korea you drive on the right side of the road. But in UK you drive on the left side of the road. This is made explicit by the law. Say, you are from the US. If you go to the UK, would you drive on the left side of the road even in absence of the law?
  - Your behavior in this case depends on other people's decision. Let's describe this more formally.

Social Interaction

		Everyone Else: Drive Left	Everyone Else: Drive Right
You	**Drive Left**	**Ok**, Ok	**Not Ok**, Not Ok
	Drive Right	**Not Ok**, Not Ok	**Ok**, Ok

What we have here is representation of a **game**.

- There are two parties involved in your decision making: i) you, and ii) everyone else. These two parties are called **players**.
- There are two directions you can drive at: i) left, ii) right. These are your **strategies**.
- There are four combinations of payoffs as shown in the 2×2 matrix.
- Given that everyone else's decision cannot be changed, it is best for your self-interest that you follow everyone else's path on this one – you drive the direction that everyone else is driving. Hence, even without the law stating that you need to drive on the left, if you go to the UK, you would be driving on the left. It turns out that your pursue of self-interest also assures wellbeing of other people in this case. However, you will soon find out that the pursue of self interest can lead to an outcome that no participant would prefer.

Defining Game Theory

- Game Theory: is a way of understanding interactions between one another based on the constraints that limit their actions, motives and beliefs regarding to what the other person might do.
  - Lets take an example.
- According to the Stern Review, "The scientific evidence is now overwhelming: climate change is a serious global threat, and it demands an urgent global response."
  - You can read the review here
- Although we know that climate change is a serious issue, and we also know that we can delay the impacts by reducing consumption of energy-intensive goods, switching to different energy generating technologies, and adapting environmentally friendly behavior (car-pooling, cyclying), we tend to neglect this issue.

Defining Game Theory

- Now let's run a quick thought experiment. Let us suppose that climate change is a concern subjected only to you and your actions can solely control climate change. Would you be more inclined to adapt more environmentally friendly behavior? Perhaps, yes.
- The issue of climate change and its adverse impacts is what we call **social dilemma**. Although we know that it is detrimental, we tend to make choices based only on our personal self interest, forgetting how our choice might affect others or our future generations. It is even more convoluted, because if I am the only one who is adjusting his/her behavior in favor of climate change, nothing different will happen.
- This makes me think, "Why should I make sacrifices?" With this thought we move on with our own "business" – pursuing our self interest and ignoring how my actions might affect others.
- In fact, many other existing social and racial issues can be argued accordingly.

Social Dilemma and The Tragedy of the Commons

- **The Tragedy of the Commons.** When we live in a society, we interact with one another. However, not all of the goods/products or resources have clear-cut ownership. You should note that many resources are in fact not owned by anyone but shared. These "common" resources are often overexploited. For example, one could turn the lights off in segements of a public library that is not in use. One could pick up a bag of trash from the middle of the city street.
  - But why would one voluntarily do so?
- If I go and pick up the trash from the middle of the street and place it in the dumpster (couple of miles away from the site), I have to go through some "unnecessary" hard work. But it is not only me who benefits from my action, every passerby will reap the benefit. So why would I want to do so much of work for everyone else, who are just free riding off of my effort? The others are known as **free riders.**
  - With this rationale of pursuing self-interest I won't pick up the trash and it will be there for a while.
- In this and similar situations, it is necessary for the government to resolve moral conflicts that human face in pursuit of their self-interest.

Part 2. Basic Elements of Game Theory

- **Game Theory** is a tool that can be used to model social interactions.
- My action will not only affect me but will also affect you. Similarly, your action will not only affect you but also affect me.
- We will formally look at some situations that depict social dilemmas as discussed in the previous slides. Then we will see if they can be solved.
- Elements
  - Players (two or more than two, will be limited to two for the purpose of understanding)
  - Strategies (actions that a player can choose)
  - Payoff (end result)
- As an example, say there are two farmers (players): *i*) Anil and *ii*) Maya. They need to decide whether they want to grow rice or potatoes–they can only grow one crop at a time. Anil is better at growing potatoes, whereas Maya is better at growing potatoes. The two farmers need to decide on division of labor. They are both from the same and they sell their crop in the village market. If they bring less rice (potatoes) to the market, the price of the commodity will increase. Let's portray their interaction.

Part 2. Basic Elements of Game Theory

		Maya	
		Rice	Potatoes
Anil	Rice	*Both produce rice.* *Abundance of rice in market, low price.* *Shortage of potatoes.* *Anil is not producing what he is good at.*	No over production of both. High price of both. Both farmers producing what they are bad at.
	Potatoes	No over production of both. High price of both. Both farmers producing what they are good at.	*Abundance of potatoes in market, low price.* *Shortage of rice.* *Anil is not producing what he is good at.*

Payoffs

		Maya	
		Rice	Potatoes
Anil	Rice	*Anil gets 1, Maya gets 3*	Both get 2
	Potatoes	Both get 4	*Anil gets 3, Maya gets 1*

What we have done here is, using the 2 by 2 matrix from the previous slide, tallied the payoffs together. Note that there are two strategies and four outcomes:1) Anil Rice, Maya Rice, 2) Anil Rice, Maya Potatoes, 3) Anil Potatoes, Maya Rice, and 4) Anil Potatoes, Maya Potatoes. For each of these outcomes, there are payoffs, as shown inside the cell of the matrix. Now given the payoff matrix, can we predict who is going to grow what kind of crop?

Best Response or Dominant Strategy

- The prediction of who is going to do (grow) what depends on the **best response**. Note that your payoff depends on not only what you pick to grow but also what the other person picks to grow. So, your best response is a strategy which makes you better off regradless of what the other person picks to do (or grow).
- Lets assume that you are Anil.
  - Given that Maya grows rice, you are better off growing potatoes
  - Given that Maya grows potatoes, you are still better of growing potatoes
- So, no matter what Maya grows, Anil is always better off growing potatoes. So, growing potatoes is Anil's **dominant strategy**.
- In a similar way, you should be able to see that Maya's dominant strategy is to grow rice.

Equilibrium outcome

		Maya	
		Rice	Potatoes
Anil	Rice	*Anil 1, Maya 3*	*Anil 2, Maya 2*
	Potatoes	*Anil 4, Maya 4*	*Anil 3, Maya 1*

Anil's dominant strategy is growing potatoes, so he chooses to grow potatoes. But he could land on either cells as shown by the dotted circle in blue – where he lands depends on what Maya chooses to grow.

Maya's dominant strategy is growing rice and she could land on either cells as shown by the red square – where she lands depends on what Anil chooses to grow.

Now given that both Anil and Maya choose their dominant strategy, They will end up in a cell shown by both the red quare and blue circle – In this case Anil produces potatoes and Maya grows rice, both end up doing what they are good at.

Equilibrium Outcome. An outcome obtained when both players play their dominant strategy Anil grows potatoes, Maya grows rice.

Equilibrium Outcome

- Note that equilibrium is state that would not change unless something from the outside changes the state of being.
- Here, Anil choosing to grow potatoes and Maya choosing to grow Rice is the state of equilibrium. Since, this is an equlibrium attained after both players playing their dominant strategy, this is also called the **dominant strategy equilibrium**.
- If both players in a game have dominant strategy, the game will have a dominant strategy equilibrium. However, it is not necessary that a player will have a dominant strategy.
- In game theory, if everyone plays their dominant strategy (best response), the equilibrium that is obtained from this is also called the **Nash Equilibrium**.

Practice Question. 4.1

		Anna	
		football	cinema
Brian	football	Brian 3, Anna 5	Brian 1, Anna1
	cinema	Brian 4, Anna 3	Brian 6, Anna2

1. Find the dominant strategy for Brian and Anna, respectively.
2. Is there a dominant strategy equilibrium? If yes, what is it?
3. Is there a Nash equilibrium? If yes, what is it?

Part 3. Prisoners Dilemma

- Earlier we saw that both Anil and Maya played their dominant strategy, and they ended up with the most efficient outcome – Anil and Maya both grew crops they were good at growing
- However, it is not always the case that picking the best interest strategy leads to the most efficient outcome. Hence, we have a case of dilemma, which is also known as the prisoner's dilemma
- Lets consider the case of Anil and Maya facing a different problem. Anil and Maya are trying to decide a way to deal with the pest insect that destroy their crop. They have two options.
  - Terminator: It is a chemical that kills pests but also leaks into the water system, which is not healthy.
  - Integrated pest control (IPC): Instead of using chemicals, this option is using benefitial insects that will eat pest insects.
- Again, we can qualitatively write out the 2 by 2 matrix for this game as follows.

Prisoners Dilemma

		Maya	
		IPC	Terminator
Anil	IPC	*Beneficial insects sprayed, will eat pests* *No water contamination*	*Maya's chemical will spread in Anil's field and kill beneficial insects* *Limited water contamination*
	Terminator	*Anil's chemical will spread in Maya's field and kill beneficial insects* *Limited water contamination*	*Major water contamination* *Requires costly water cleaning devices (filtration)*

The above game can be written using the following payoff matrix, considering the cost and benefit of each outcome.

Prisoners Dilemma

		Maya	
		IPC	Terminator
Anil	IPC	*Anil 3, Maya 3*	*Anil 1, Maya 4*
	Terminator	*Anil 4, Maya 1*	*Anil 2, Maya 2*

To decide what Anil is likely to play, we need to see his dominant strategy.

1. If Maya uses IPC, Anil is better off using Terminator.
2. If Maya uses Terminator, Anil is better off using Terminator.

Given that no matter what Maya does, Anil is better off using Terminator, this is his dominant strategy. In a similar way, you should be able to see that using Terminator is also Maya's dominant strategy. The play their dominant strategy and end up in cell given by the red square. Is this the cell where both players get the maximum payoff? No, because in cell given by the green circle, payoff is higher for both. So, it turns out that playing the dominant strategy does not assure the best outcome, hence, a dilemma.

Prisoners Dilemma

- The name prisoner's dilemma comes from the interrogation technique used by detectives. Let's take Louise and Thelma, would are suspects of a crime.
- Both are being questioned in separate rooms. Each has two strategies: i) confess (state that the other person was involved in the crime), ii) don't confess (deny that the other person was involved).
- Here is how the payoff looks like:
  - If both don't confess, both are released after a few days of questioning
  - If one confess but the other deny, the person who confess is set free but the one who denied go to prison for 10 years
  - If both confess, the both go to jail but the sentence is reduced for 5 years.

Prisoners Dilemma

		Louise	
		confess	don’t confess
Thelma	confess	*Thelma 5, Louise 5*	*Thelma 0, Louise 10*
	don’t confess	*Thelma 10, Louise 0*	*Thelma 0, Louise 0*

It has to be seen that the dominant strategy is confessing for both Thelma and Louise, which sends them to prison for 5 years. However, there is a better outcome (green cell), if both don’t confess. They will never get to the green cell by playing their dominant strategy.

Prisoners Dilemma in Practice

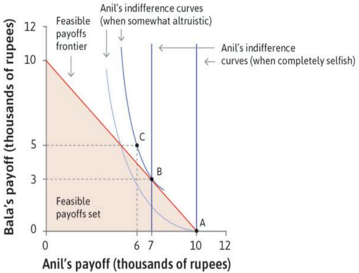
- There are several different applications of prisoner dilemma game, including major decisions such as whether to go to war.
- So far we know that seeking for one's best interest (dominant strategy) can lead to an outcome with the maximum payoff, but in some situations this is not true. Using self-interest can lead to some outcome that is not optimal.
- Here is another example that you can watch – Golden Ball
  - The Golden Ball used to be a game that thrived off of human self interest, with humans playing their dominant strategy and ending up with less efficient outcome (prisoner dilemma problem).
- However, one participant came up with an ingenious way of solving the dilemma. You can watch this here Golden Ball Solve
- The game theory problems that we through so far can used as a model to explain several practical cases that we see in the world.

Part 4. Are people solely driven by self interest?

- Prisoners dilemma occurs in instances when humans are solely concerned about their own self and try and free ride on other other's coperation.
- There is a big debate in the field of Economics as to whether people are driven solely by self interest.
  - Studies have found that human can be driven by self interest but at many times they care for others as well (true altruistic nature).
- An altrustic nature can be defined as a person's behavior such that she/he is willing to bear cost to help another person.
  - In the case of Anil and Maya's decision of adapting a strategy to eliminate pest, Anil can care about Maya's benefit, as well as his. If this happened, given that Maya decided to use IPC, Anil wouldn't have used the Terminator. In this example, Anil would be willing to forgo 1 unit of payoff because this would have resulted in 2 units of loss to Maya.
- We should be able to see how altruism can solve the issue that we face in prisoner's dilemma problem between Anil and Maya.
- In our next slide, we will see how preferences of an altruistic person looks like through the lens of indifference curve.

Altruistic Preference

Figure 1: Altruistic Preference and Indifference Curves



Anil and Bala are neighbors. Anil wins a lottery of Rs. 10,000. Now, Anil gets to decide how much he wants to keep vs. how much he wants to share with Bala. The most extreme points are the intercepts (case when Anil keeps all of the money and Anil gives it all to Bala).

Note that Anil's frontier is given by the downward sloping line. If Anil only values himself, his indifference curve will be the vertical lines, and he will pick point A, where his indifference curve meets the frontier. This is also the corner solution. Now, if Anil's preferences are of altrusitic nature, his indifference curve will be downward sloping. Based on the Figure 1, he will choose point B, where he keeps Rs. 7000 and gives Rs. 3000 to Bala.

Part 5. Prisoner's Dilemma and Public Goods

- The case of prisoners dilemma can be seen in many practical situations that involves decision to invest in common resources such as irrigation, forestry, and climate to name a few.
- It arises because of an opportunity to free ride – a person seeking benefit from other's investment.
- Let's look at an example. There are four farmers trying to decide whether they want to contribute to construct an irrigation canal, which is a public good. So, if one farmer contributes, all will generate benefit from the canal, with each gaining \$8. Say the cost of contribution is \$10. You are one of the farmers, so your decision of whether to contribute or not depends on the decision of other three farmers. There are four cases pertaining to the remaining three farmers:
  - i) all 3 contribute, ii) 2 farmers contribute, iii) 1 farmer contributes, iv) all 3 don't contribute
- I will use case i) (when the remaining 3 farmers contribute) to show what your optimal decision will be in the next slide.

Part 5. Prisoner's Dilemma and Public Goods

When the remaining 3 farmers contribute	
Benefit from 3 farmer's contribution	$3 \times \$8 = \$24$
Benefit from your contribution	\$8
Cost of your contribution	\$10
Net benefit for you if you contribute	\$22

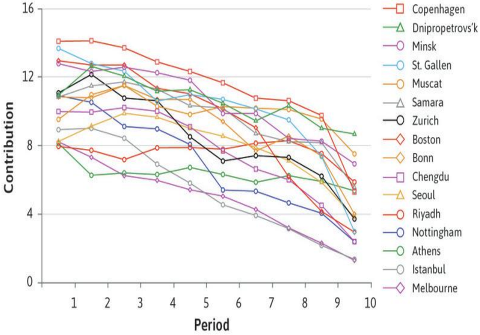
- As you can see, the net benefit if you contribute (\$22) is less than what you would be getting if you decide not to contribute (\$24). Ofcourse, this is only one of the four cases, when three farmers decide to contribute. You can try what happens to you benefit when you contribute vs. when you don't contribute for the remaning 3 cases.
- You will find out that you are always better off not contributing, not matter what the other farmers do. So, not contributing is a dominant strategy here – given that you are solely driven by the motives of self interest.
- Now, altruism can solve this problem – if you cared about other farmers, you might be willing to contribute to building irrigation canal.
- However, in practice the degree of cooperation varies. This kind of irrigation problem (and other similar problems) was tackled by Elinor Ostrom, a political scientist, who won a nobel prize in economics. Her work focused in India and Nepal.

Part 6. Experiments, Contribution in Public Goods and Peer Punishments

- Throughout the world economists have conducted several experiments to check one's affinity towards contributing to public goods (altruistic behavior).
  - Note that free riding is a form of hurdle that impedes a person from contribution towards public goods if it were not for free riders.
- Keeping the problem of free riding in mind, lets look at the following experiment that is conducted for 10 rounds similar to the one involving Kim, with 4 people in a group:
  - In each round the participants of the experiment are given $20
  - They are asked to decide on a contribution to the pool (public good) from their share of $20
  - For every dollar contributed, each person in the pool receives $0.40.

Contribution in public goods

Figure 2: Contribution in public goods (repeated game)



It can be seen that the contribution of the group is not zero, meaning that people are fine contributing to the public pool. Although contribution varies widely across different cities, a consistent pattern can be seen – as you play more rounds, the average contribution amount decreases. This can be because people who contributed initially are fed up with free riders, hence, they cut down on their contribution.

Let's work out the outcome of the game

- Say, you are playing the game, and say all other three members of the group contributes \$10 each.
- If you don't contribute, your return in this case is $=\$20(\text{original share})+(0.4\times\$10\times 3(\text{people}))=\$32$.
- If you also contribute \$10, your return is $\$20(\text{original share})\text{-}\$10(\text{contribution})+(0.4\times\$10\times 4(\text{people}))=\$26$.
- So according to the above calculation, you are better off not contributing.
- Now, let's look at the results from some experiments for 10 rounds.

Practice Question

- Four farmers are deciding whether to contribute to the maintenance of an irrigation project. For each farmer, the cost of contributing to the project is \$10. But for each farmer who contributes, all four of them will benefit from an increase in their crop yields, so they will each gain \$8. Which of the following statements is correct?

1. If all the farmers are selfish, none of them will contribute.
2. If one of the farmers, Kim, cares about her neighbour Jim just as much as herself, she will contribute \$10.
3. If Kim is altruistic and contributes \$10, the others might contribute too, even if they are selfish.
4. If the farmers have to reconsider this decision every year, they might choose to contribute to the project even if they are selfish.

Part 7. Ultimatum Game I

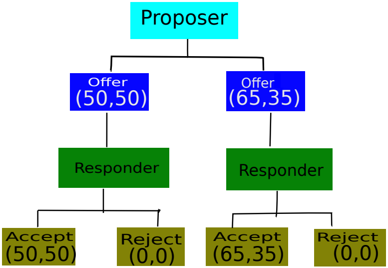
- Let's consider a two person one-shot game known as the ultimatum game
- The subjects are invited to play a game in which they win some money
  - how much they win depends on how the subject and other participants play the game
- A pair of two is randomly assigned. One person acts as a Proposer and the other as Responder
- Proposer is given \$100, which the Responser know the Proposer has to split
- The split is x+y=\$100, where x is Proposer's sum and y is Responser's amount
- Following the split, the Responser chooses whether to accept the split or reject
  - if split is rejected, no one gets any thing. If accepted, they get the designated amount.
  - If Proposer offers \$35 to the Responser and if the offer is accepted, Proposer gets \$65 and Responser \$35
    - If the Responser rejects, both get nothing!

Ultimatum Game I

- In other words, we have a take-it-or-leave-it type setting here.
- Here, economic rents (money received by the Proposer) is being shared. If negotiation is successful, both parties received a rent (a share of the pie), and if it fails they receive nothing.
- If the deal goes through, the Proposer gets a rent of $65, whereas the Responder gets a rent of $35.
  - If the Responser says no, she let's go of $35 of the rent (opportunity cost)
- We can portray the game by using a game tree. Note that this is a sequential game, which is different from simultaneous games that we have seen in the past.
  - Here, the Proposer moves first and then the Responder moves after. These types of sequential decisions can be depicted using a game tree.

Ultimatum Game

Figure 3: An Ultimatum Game between the Proposer and the Responser



This game has a sequential setup. First, the proposer decides what to offer. The figure above plots the possible outcome when the Proposer offers \$50 vs. \$65. The Responder then sees the Proposer's offer – the ultimate outcome of the game depends on whether the Responder accepts the offer or not. In both cases, if the Responder rejects the offer, both parties receive 0. Hence, the question might be what factor determines the minimum acceptable amount from the Responder's view point?

Ultimatum Game: the Minimum Acceptable Offer

- What is the minimum acceptable offer for the responder? The depends on the reponders attitude regarding reciprocity. If the responder highly values reciprocity, the minimum acceptable offer is likely to be high.
- Let us term R as the level of reciprocity of the Responder. If R is a large number, the responder cares about the Proposer acting in a generous manner; if R=0 she does not care.
- The Responder's satisfaction of rejecting the offer is R×(50-y). For the Responder to reject the offer, her satisfaction from rejecting the offer needs to be higher than the offer (y) itself.
- The minimum offer (y) can be found as:

$$\begin{aligned} R \times (50 - y) &> y \\ y &< \frac{50R}{1+R} \end{aligned} \tag{1}$$

Conclusion

- Game theory is a model that is used to depict decisions that are made in an interactive social circle, such that your payoff is not just dependent on what you choose but also depends on choices of other people.
- Prisoners dilemma is a puzzle that arises once people play their dominant strategy but do not attain what is the best outcome.
  - It arises due to the problem of free riding when it comes to public resources
- We can see that in situations that concerns public goods, playing the dominant strategy may not lead to a constructive outcome.
- Altruism can solve the problem of dominant strategy, but still may be impractical if there are way too many players in the game.