

PRINCIPLES OF BEHAVIORAL ECONOMICS

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Week 53

Lecture 53

Hello everyone, this is Lecture 53 of the course on Principles of Behavioral Economics. We are now discussing the topic of strategic interactions, and under that, we were discussing analytical or classical game theory. So, under classical game theory, in the last two modules, we introduced different components of games or elements of games, different concepts including Nash equilibrium. And here, we are going to talk about sequential games. So far, we have actually discussed normal-form games, which are basically simultaneous games.

Next, we are going to talk about sequential games, followed by types of games. Games with multiple stages are called sequential games. To analyze such games, it is often useful to use a tree-like representation called the extensive form. Let us consider a game with two stages. In the first stage, Player 1 plays U or D. If Player 1 plays D, both players get a payoff of 2.

So, this is how we can write the game. This is the move of only Player 1. He has two options: U or D. If Player 1 plays D, then the game ends there, and both players get a payoff of 2. If Player 1 plays U, it is Player 2's turn in the second stage. Player 2 plays L or R. So now, we are talking about Player 2.

Player 1 can play L or he can play R. If player 2 plays L, player 1 gets 5 and player 2 gets 1. If player 2 plays R, both get 0. So what are the Nash equilibria of this game? What we do here is begin from the end.

Player 2 will first check his payoffs given his strategies. If he chooses L, he gets 1. If he chooses R, he gets 0. So he would choose 1. And if he chooses 1 or if he chooses

L, then player 1 would compare his payoffs from U and D. U gives player 1 a payoff of 5, while D gives player 1 a payoff of 2. So, of course, player 1 would prefer to play U. When

player 1 plays U, player 2 plays L. This is an extensive-form representation. A subgame of a game is any part of that game which in itself constitutes a game. A subgame perfect equilibrium is a strategy profile that constitutes a Nash equilibrium in each subgame.

So, if I write this game again here, then this is basically a subgame, and this game has only one subgame. One way to find subgame-perfect equilibria or subgame-perfect Nash equilibrium which we, in short, call SPNE, is to start at the end and use backward induction. So, the method I just explained in the previous slide is basically the method of backward induction. Following this,

the only subgame-perfect Nash equilibrium is U L, that is, (5, 1), which we have already discussed. The NE in the entire game requires player 2 to play R in the subgame, which is not NE in the subgame. So, what I mean here is that if I write it in a normal-form game and try to find out the Nash equilibrium, what do I see when player 1 plays U? Player 2 is better off playing L. When player 1 plays D, then player 2 is indifferent between L and R because both give him the same utility or payoff. When player 2 plays L, then player 1 is better off playing U. So, U L is definitely one Nash equilibrium.

And then, when player 2 plays R, then player 1 is better off playing D. So, D R is another Nash equilibrium. But this Nash equilibrium is not there in the subgame. This Nash equilibrium is only there in the entire game. So, let us take another example: what will be the SPNE or subgame-perfect Nash equilibrium in the following game using backward induction? So, this is what the game looks like.

Again, we start with backward induction. Now, here, player 1 again has two strategies: U and D. Player 2 can play L or R when player 1 plays U. That's why they are called UL and UR. Player 2 can play L or R when player 1 plays D. So, they are called DL and DR. Now, player 1 compares his payoffs across all strategies. He sees that if player 1 plays U, then he would definitely be better off playing R. So, UR is his strategy.

If player 1 plays D, then he would be better off playing L. So, D-L is another strategy. Now, player 1 sees that these are the two strategies that player 2 is going to play. So, what is beneficial for player 1 to play? Then, player 1 compares 1 and 2, and of course, this is bigger, so player 1 would be playing D. So, the SPNE, or subgame perfect Nash equilibrium, in this game is D-D-L.

However, the Nash equilibrium in the normal-form game is U-R. So, this is the normal-form game. You can see that when player 1 plays U, player 2 plays R; when player 1 plays

D, player 2 plays L. Player 2 plays L; player 1 plays 3. Player 2 plays R; player 1 plays U. So, U-R is the Nash equilibrium in the normal-form game. So, what it shows is that it is not necessary for the subgame perfect Nash equilibrium to be equal to the Nash equilibrium. Also, we would like to mention here that the subgame perfect Nash equilibrium is again obtained through backward induction, and it's quite possible that there are better payoffs for both players. For example, here, UL is a payoff that is strictly better than D-D-L.

So, UUL offers payoffs which are the same for player 2 but certainly better for player 1, so this is better compared to this one. Nevertheless, this is the Nash equilibrium and this is not a Nash equilibrium. So, this is all we will, for the time being, talk about extensive form games. We will be talking about extensive form games later while discussing the deviations or problems with classical game theory. Next, we talk about types of games.

Here, we are going to briefly introduce a large number of games. The primary reason is the fact that we do not have either the time or the scope to talk about or explain all possible games. This is not the purpose of this course to explain classical games of all forms. Therefore, we find it useful to classify games according to certain important characteristics, and the broad types that we will discuss are just briefly explained.

The broad types that we are going to discuss are cooperative and non-cooperative games, two-player and multiplayer games, zero-sum and non-zero-sum games, complete and incomplete information games, static and dynamic games, discrete and continuous strategies, and finally, one-shot and repeated games. Now, you understand that some of them we have already discussed, at least briefly, and some we have not. So, we are just going to introduce them to you. We begin with cooperative and non-cooperative games.

In cooperative games, the players can communicate with each other and collude. They can also enter into third-party enforceable binding contracts. Many of these types of activities are expressly prohibited by law in developed economies or countries. Many of the games that are of interest in economic situations are of the non-cooperative kind. This type of game involves forming self-enforcing reliance relationships that determine an equilibrium situation.

The nature of such equilibria is discussed later. We shall also see that many games involve a mixture of cooperation and competition, and this is true of the basic one-off prisoner's dilemma game. The next type is two-player and multiplayer games. Prisoner's dilemma situations are two-player games, and most often we have, till now, discussed only two-

player games. However, this kind of game is capable of being extended to consider more than two parties.

Having more players tends to increase the likelihood of defection, particularly in the one-off situation referred to as a one-shot game. One version of such a situation is sometimes referred to as the tragedy of the commons. This applies in cases where property rights are untradeable, insecure, or unassigned. For example, where pollution is involved. The reasoning is that with more players, it is important to defect before others do.

Only if defectors are easily detected and punished will this be prevented. The depletion of fish stocks in the North Sea due to overfishing and the resulting conflicts are an example of the tragedy of the commons. We will talk about more such instances while discussing behavioral games. behavioral games will also allow us to introduce games with multiple players in other situations instead of the resources being overused it is under supplied as with public goods like street lighting and hospitals with multiplayer games there is also the opportunity for some of the players to form coalition against others

to try and impose strategies that would otherwise be unsustainable. In economics, there is one concept of a cartel, which is more commonly associated with oligopolistic markets. Cartels are one kind of formation where people are bound by certain contracts or organizations. OPEC is the most well-known cartel. These are also examples of multiplayer games.

where these games are based primarily on cooperation and by forming the cartels they actually offer opportunity for some of the players to form coalition against others and these coalitions try to exploit the consumers, could be the resources or whatever is basically the main trade of the cartel. Next we talk about zero sum and non-zero sum games. Zero sum game was briefly introduced in the previous modules with zero sum games sometimes called constant sum games. Also the gain of one player is automatically the loss of another player. Thus the sum of the gain and losses of the players is constant. This can apply for example in derivative markets where certain transactions occur between two speculators

However, most situations involve non-zero-sum games. Furthermore, even when monetary gains and losses offset each other, the utilities of such gains and losses may not do so because of loss aversion. So, all we want to say here is that in options, we know specifically that if the writer is making money, the holder must not be, or if the holder is making money, then the writer will not be. In a similar fashion, since we talked about derivatives, in forwards and futures markets also, one party's gain is another party's loss.

So, as a result, they could be very real examples of zero-sum or constant-sum games. But these are the cases when we are talking typically about the value of the money involved or the amount involved. For instance, my 100-rupee loss would be someone else's 100-rupee gain. But it's not necessarily true that the utility associated with my 100-rupee loss is equivalent to the utility associated with the other individual's 100-rupee gain. Specifically, in the context of loss aversion, the utility from the loss is expected to be much greater than the utility from the gain.

As a result, we cannot say that one's loss is exactly matched with another individual's gain. Ideally, if we sum up all the losses and sum up all the gains, which are equal in number, then in terms of utility, there would be a much larger amount of losses compared to the aggregate gains. The next one is complete and incomplete information gain. In practice, not all players know for certain what all the payoffs are or were for each pair of strategies. This can also affect strategy or decision-making.

In some cases, a player may be uncertain regarding their own payoffs. In other cases, they may know their own payoffs but be uncertain regarding the payoffs of the other players. For example, an insurance company may not know all the relevant details regarding the person applying for insurance, a situation leading to adverse selection. In economics, again, a celebrated concept is information asymmetry, which simply implies that both parties involved in a transaction do not have equal information. If there is information asymmetry, then it has two possible impacts: one is before the transaction takes place, which is called adverse selection,

and the other one is called moral hazard. So basically, this is happening before the transaction, and this is happening after the transaction. Adverse selection implies that if you do not have the necessary information, you may select one entity or a trading partner that is not going to give you the optimum result. Suppose I am going to buy the stocks of a company. If the company did not publish its annual reports or manipulated its earnings, annual reports, profits, losses, etc., then there is information asymmetry.

The company has certain information that is very important for me before I make the decision to invest in that company, but I actually do not have that information. So if that company is actually engaged in fraudulent reporting of its income statement, profit and loss statements, then by investing in that company's shares, I may get into trouble later when the company declares itself insolvent. So what happens is that, first of all, because of information asymmetry, I picked the wrong company. So this is adverse selection, and

when the company lands into trouble and I also land into trouble, then that is basically the moral hazard problem. So this is what we are referring to: that an insurance company may not know all the relevant details regarding

The person applying for insurance is a situation leading to an adverse selection problem. Likewise, bidders at an auction may not know the valuations that other parties place on the auctioned item. Games with incomplete information are, unsurprisingly, more difficult to analyze. Of course, when there is not complete information, Then we need to make a lot of assumptions, as a result of which reaching the optimum solution is always covered with a lot of precariousness.

Then we talk about static and dynamic games. Static games involve simultaneous moves. The PD game, or prisoner's dilemma game, is a simultaneous game, meaning that the players make their moves simultaneously without knowing the move of the other player. In terms of analysis, the moves do not have to be simultaneous in chronological terms, as long as each player is ignorant of the moves of the other players. So, the two players are kept in two different rooms.

One police officer may approach them one by one, but as long as they are not informed about who is interrogated first and what his response has been, then it actually doesn't make any sense whether prisoner one is approached first or prisoner two is approached first. So, in that case, we would also consider it as a simultaneous move scheme. Many life situations involve dynamic games These involve sequential moves, where one player moves first and the other player moves afterward, knowing the move of the first player. So essentially, we all know that the difference between static and dynamic is that anything that is static is constant with respect to time.

So simultaneous games are constant with respect to time. So we call them static games, and extensive forms or sequential form games basically involve time, which is why we call them dynamic games. The ultimatum bargaining game is an example of a dynamic game. The order of play can make a big difference to the outcome in such situations. The ultimatum bargaining game is something we have not talked about yet.

That's a very popular behavioral game where the structure is such that there is one proposer, most commonly, and one responder. One proposer makes a proposal, suggesting a split of an amount which he or she has. Suppose it is 100 rupees with me, and I am the proposer. There is another responder. So I need to offer a split of 100 rupees to the responder.

The responder may accept it or reject it. Since this is moving in sequence, that's a dynamic game. We'll discuss ultimatum games at length in later modules. The next one is discrete and continuous strategies. Discrete strategies involve situations where each action can be chosen.

From a limited number of alternatives. In the prisoner's dilemma game, there were only two choices for each player: to confess or not confess, or we can say to cooperate or defect. Thus, this is a discrete strategy situation. Again, most of the games we have discussed so far are all discrete strategy situations. In contrast, a firm in oligopoly may have a virtually limitless number of prices it can charge.

This is an example of a continuous strategy situation. So basically, when one has an array of things to offer, we can call it a continuous strategy. In fact, in an ultimatum and bargaining game, we can design it as a discrete strategy game. We can also design it as a continuous strategy game.

How? We may discuss it later. So, because of the continuous strategy situation, the analytical approach is somewhat different in terms of the mathematical techniques involved. Finally, we talk about one-shot and repeated games. Many short-run decision scenarios in business, such as pricing and advertising, are best analyzed as repeated games.

In that, there is a continuous interaction between competitors who can change their decision variables at regular intervals. Some of these games may involve a finite number of rounds where the end of the game can be foreseen, while others may seem infinite or open-ended. Long-run decisions, such as investment decisions, may resemble the one-shot situation. Although the situation may be repeated in the future, the time interval between decisions may be several years, and the next decision scenario may involve quite different payoffs. Now, we will summarize the analytical game theory that we have discussed so far.

Of course, not the types, but the observations that we developed from the initial discussions of deriving the Nash equilibria and the differences that we observed. Analytical game theory admits descriptive and normative interpretations. According to the descriptive interpretation, game theory captures the manner in which people behave when they engage in strategic interactions. In this view, game theory predicts that people will jointly choose an equilibrium strategy profile.

Specific predictions, of course, will depend not only on the game played but also on the equilibrium concept that is employed. According to the normative interpretation, game

theory describes how rational agents should behave when they engage in strategic interaction. So, one is about how they behave, and the other, as you already know, the normative interpretation is about how they should behave. In this view, game theory says that players should jointly choose an equilibrium strategy profile. Again, the specific advice offered by the theory will depend on the game played and the equilibrium concept employed.

Either way, living up to the demands of game theory is extremely challenging. To employ backward induction, for one thing, you need to think all the way ahead until the end of the game. The very last round you might find yourself playing. And then work your way back in time to the present moment. One thing to notice is that the nature of the game is defined by the distribution of utilities in the matrix.

What makes one game a prisoner's dilemma and another game a battle of the sexes is the manner in which the utilities are distributed. Hence, if you do not know how much utility each player derives from each outcome, you do not know what game they are playing. This is a conceptual point. But it can lead to practical problems since, unless you know what game people are playing, you cannot even begin to use the tools of game theory to analyze the interactions. Another thing to notice is that a game does not necessarily have a unique equilibrium.

And analytical game theory in itself does not contain the resources required to identify which equilibrium people will or should play. So it basically presents the equilibrium suggested by, say, the Nash equilibrium, either in pure strategies or in mixed strategies. But it doesn't say which one people should play. There could be multiple Nash equilibria. This fact causes another practical problem.

While the theory can be interpreted as predicting that the outcome of strategic interaction will or should be a Nash equilibrium, this is only to say that some Nash equilibrium will or should obtain. In this sense, then, the theory is indeterminate. And because some games have an infinite number of equilibria, the theory is radically indeterminate. If we want determinate predictions, we must augment the theory with additional resources.

The most famous such effort is the theory of focal points, due to 2005 Nobel laureate Thomas C. Schelling. According to this theory, some equilibria tend to stand out in the minds of the players. They are basically called focal points. Schelling predicts that people will frequently succeed in selecting such an equilibrium.

The precise feature of an equilibrium that makes it stand out in the minds of the players is far from obvious; what makes an equilibrium a focal point is actually not explained by any theory. So with this, I conclude this module and also bring the discussion on analytical game theory to an end. Next, we will start discussing problems that are faced with analytical or classical game theory. These are the references.

Thank you.