Strategy: An Introduction to Game Theory
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Lecture - 23

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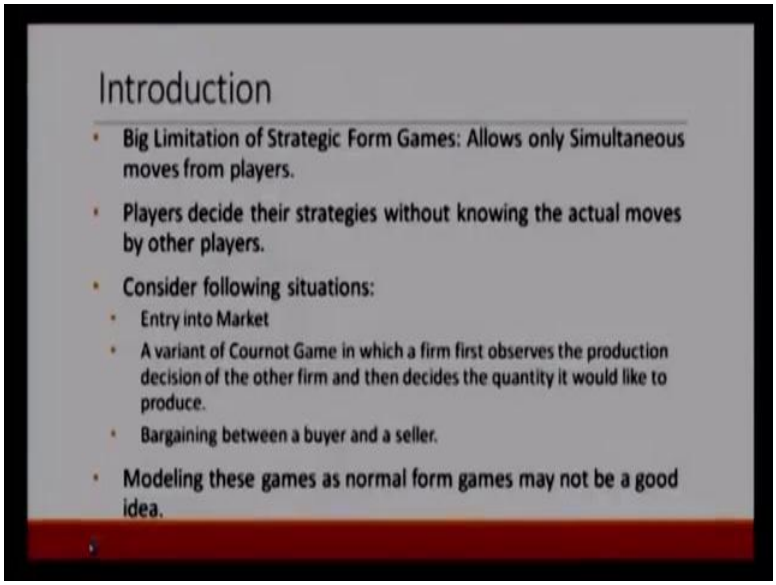

Welcome to the mooc course on Strategy: An Introduction to Game Theory. In this module we are going to talk about a different form of game we call extensive form game. We will shortly learn what we mean by extensive form game. So far the game that we have seen is classified as normal form game. We also call them strategic form game.

What happens in the strategic form game is, we have three information, three pieces of puzzles, and one set of decision makers we call them players. Second, that all the players have certain strategies that they can imply in the strategic interactions and then, based on the different strategic profile, we have different payoff for the players. What is the rule of the game here is that all the players would move simultaneously, that is the keyword.

A normal form game allows only simultaneous move from the players. Now, what do we mean by simultaneous form? It does not mean that everyone has to move at the same instance. It only means that when a player takes his action is not aware of the actual action taken by all other players. So, that is why we call it simultaneous move game. So, even if they are moving at different time, it is like simultaneous because they are not aware of others action. That is the keyword that players are not aware of others action,

others actual actions. They are aware of the different actions that different players can take. They are not aware of the actual actions taken by the players, but in many instances we know whenever a decision-maker has to move, he knows the action taken by other players.

Let us take an example. We call it entry game that is entry into market. Let us say a firm is thinking of entering in the market. Now, the firm that is present in the market would see whether other firm has entered or not and then, the firm that is already present in the market would take necessary action a variant of Cournot game in which a firm first observes the production decision of the other firm, and then decides the quantity it would like to produce. Similarly, in bargaining, when bargaining happens between a buyer and seller, buyer observes the price offered by the seller and then, buyer makes account, your offer and so on. So, both are aware of the actions taken by other players. So, then still modeled as normal form game that we will see that it may have some problems. So, we should figure out a different way of representing them.

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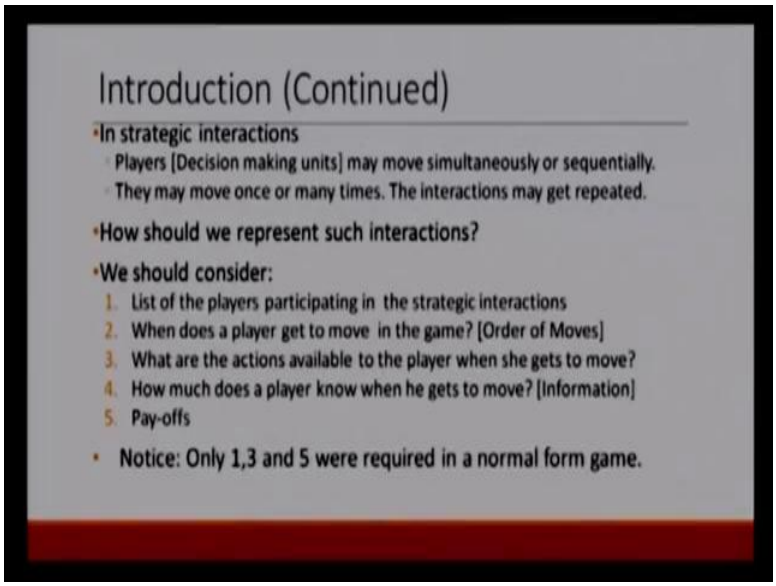

Just to give you simple recap what happens in the strategic, any strategic decision, the players may move simultaneously or sequentially. Sequentially meaning they move after observing the action taken by other players and also, they may move once or many times their interactions may get repeated also, but in normal form game, we allow for as it is that players are moving only once and this statement will become clearer little later,

probably in the next module when we differentiate between strategies on actions. How should we represent such interactions? We have figured out a way of representing a normal form game, but here let us look at in general what are the things required we described as strategic interaction. What do we need to give list of players participating in strategic interaction this term was present? The piece of the puzzle was required even for the normal form game.

Second, we want to know when a player gets to move in the game, any order of the game. This was not required in the normal form game as players move simultaneously and third, what are the actions available to the player when she gets to move. It is same here we are describing the action. Earlier also we were talking about something similar strategies. So, actions are similar to strategy that again they are different. Next thing required is, it is very important, but I would not emphasize it today. One of the module would be dedicated to discuss this particular thing. So, how much does a player know when he gets to move? So, what we are? So, we are allowing for possibilities that normal form game in which player does not know the actual move of the player or any sequential move game in which player is aware of the action taken by other player. Both could be representing and again, they payoffs.

You should notice that 1, 3 and 5 were required in a normal form game. What we are adding? In fact, this representation that we are adding number 2 and number 4. So, one can say if one has to describe the game, it makes in more details than it makes much more things describe. So, one say that normal form game is reduced form representation of a strategic interactions.

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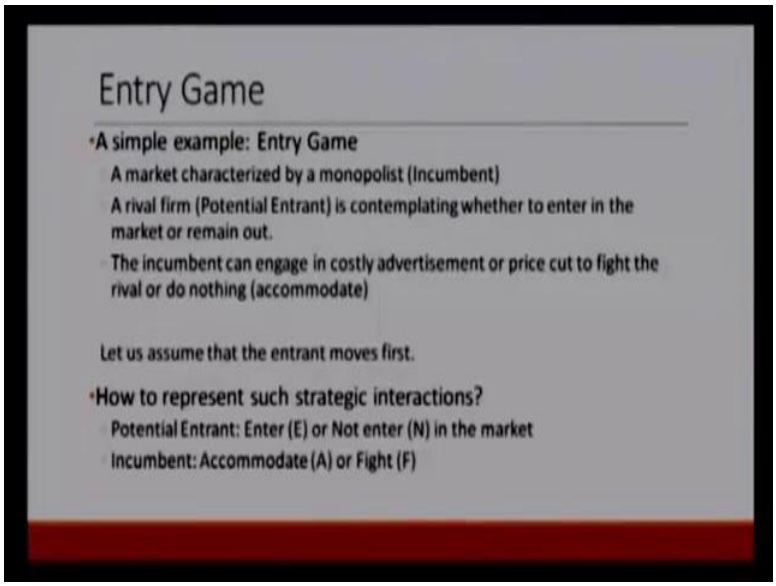

Let us take an example as I already give you this. What do you mean by an entry game? We can say that there is a market. By market we do not mean a market place. A market is precisely where buyers and sellers come together to exchange a particular good. So, let us say this market is characterized by a monopolist. You can think that this is a market for food business. So, the only restaurant in the town or it can be only three sellers in the town. It does not matter as long as they are selling one particular good and there is only one seller. We say that market is characterized by a monopolist. So, we will call this firm as incumbent as it is already present in the market.

Now, the next step is rival firm we will call them entrant because it is thinking of entering in the market is contemplating, whether to enter in the market or remain out of the incumbent. That is monopolist can engage in costly advertisement or price cut to fight the rival or do nothing. We can assume that entrant moves first. Let us say that incumbent is not able to figure out beforehand whether entrant is going to enter or not. Only once entrant enters in the market, monopolist observes it and then, takes the action. So, how do we represent such strategic interaction? First, we have to give the list of the players. There are two players. One is incumbent and second is potential entrant. Potential entrant has two actions available. One is either to enter in the market or not enter. Enter we will be representing sort by E and not entering will be represented by N.

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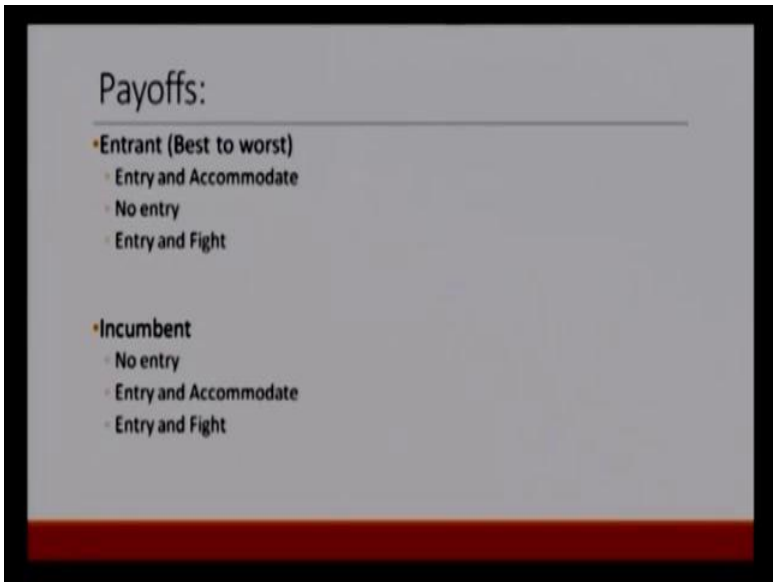

Next for incumbent, we have again two actions available either to accommodate the entrant that is A or fight that is engage in costly price advertisement or price cut. What are the payoffs? We do not know the actual payoffs. One will have to do market survey to figure out, but we can say that for entrant, the best outcome is that entrant enters and incumbent accommodates. In that way an entrant will get some market share, so that gets for the entrant. Second best option is for the entrant is, the entrant does not enter in the market and third is that entrant enters and incumbent fights because fighting would be costly for both of the firms.

Notice one more thing that if entrant decides not to enter in the market, then game would end because in that case, incumbent does not make to take any decision whether to accommodate or fight. How about incumbent because incumbent is the monopolist. So, most preferred outcome for the incumbent would be that entrant does not enter in the market, so no entry. Second best outcome would be entry from the entrant and incumbent accommodates, and the worst outcome for incumbent would also be that entrant enters and incumbent fights. Notice that it is also very well possible that order of the best to worst order of the payoffs would be different, and this is our assumption which would be true in several market, but which may not be true in the several other markets. So, this example I am taking very specific payoffs and of course, outcome would depend on those specific payoffs.

We cannot assume blindly that in all ingredients, this would be the order of payoffs. So, what we can say as we do not know we can give this. So, based on this order because as we have learned already in the other module that the order is the most important thing, not the actual payoff. So, we can simply give it let say 3, 2, 1 and here also we can go for the same order 3, 2, 1. By just illustration that we do not need to give the exact same number, we just make to maintain the order. So, here we are going to give 1, 0 and -1.

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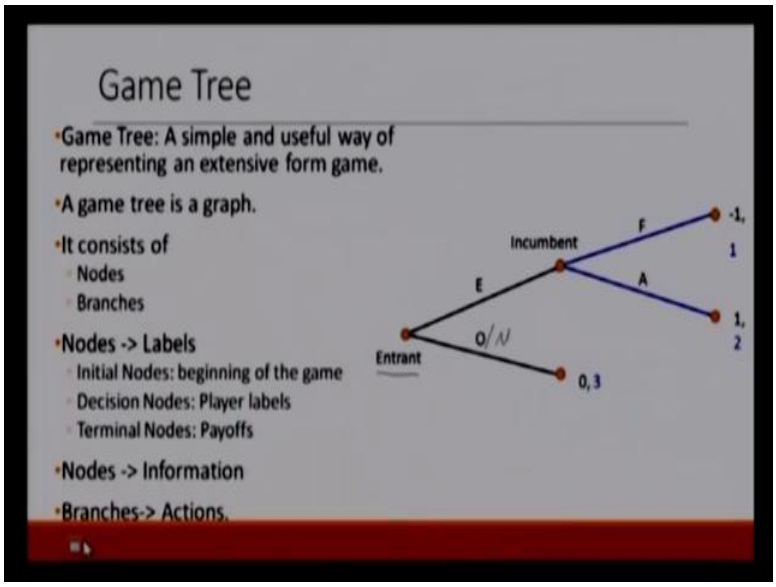

So, let us come to Game Tree. What is Game Tree? Remember that in normal form game we were using bi-matrix table to describe the game. Bi matrix table contained list of players. It also gave all the actions or the strategies that can be implied by players and also respective payoffs. So, similarly game tree is the nice way of giving all the five pieces of puzzle that we have written here. These are the five pieces.

So, let us look at it here. Entrant can either enter or remain out. Earlier I said that not enter you can use O or N. Earlier I said N, but here I have written O. I am so sorry about it. So, entrant can either enter or remain out of the market. If entrant remains out of the market, then entrant gets 0 as notice that this is the second most preferred outcome for the entrant and incumbents gets incumbent gets 3, but if entrant enters in the market, then incumbent gets to either fight or accommodate. So, these are the two things that incumbent can do, and these are the respective payoff that we have written in the earlier slide.

So, what is the game tree? So, game tree is basically a simple and useful way of representing an extensive form game. Basically game tree is a graph which consists of nodes. These are nodes. These orange disk, small disk, they are nodes and then, we also have branches. What are the branches? The line that connects two nodes is called a branch. So, we have branches. So, we have one branch here, another here and these are the four branches.

Nodes should have three different kinds of nodes. We talk about one is initial nodes. What does it indicate? It indicates the beginning of the game. So, here this node is the initial node, then we have second kind of node and these are called decision nodes where players get to take decision. So, players get to take decision at this node and this node and also, this node. Notice that this node is initial node as well as a decision node. A initial node could very well be a decision node and then, we have terminal nodes. Which are the terminal nodes? This one, this one, this one are terminal nodes. It indicates the ending of the game and thus, also it will be the payoff that the players would get.

Notice that one all the decision nodes we have written a name of the player who would get to move at that particular node. Like here in this decision node, entrant gets to take action. At this decision node, incumbent gets to take action. This node is not a decision node. So, we do not label it with a player name, but this node is a terminal node. So, it is label using the payoffs. We will also notice that all five pieces, one piece was information nodes also relate to information, but I am keeping for other modules for simple game. We do not need to understand information. Little later we will need to understand the role of information in extensive form game and branches. Branches are labeled with actions. Like this branch is labeled with E. What it says that when entrants takes action E, then incumbent gets to move. So, this branch is labeled with E that is the action taken by entrant.

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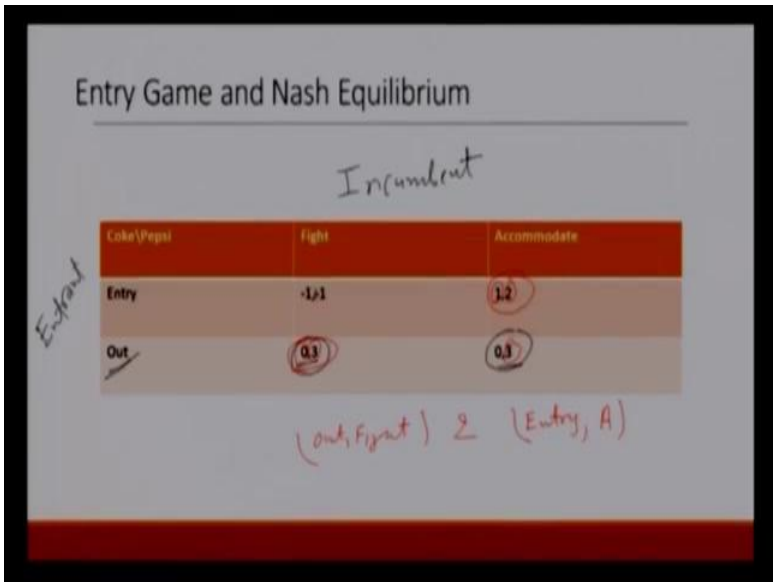

So, this is the game. Let us say if you want to represent the entry game is in normal form game, can we do that? Of course we can do that. Normal form game has little less structure as it is reduced form. What we need is list of the players that we have here. We have entrant and here we have incumbent and then, entrant can of course enter in the game or remain out of the game, and incumbent can either fight or accommodate. How can we write the payoffs? Let us look at it. It is very clear that if entrant enters and incumbents fights, then the payoff is minus 1 and 1. This would be plus 1. Similarly, when entrant enters and incumbent accommodates, then the payoffs are 1 and 2 respectively.

What if entrant remains out? Then, incumbent does not get to move. Then, what would be the payoff? Notice I have written 0 3 0 3 which is the payoff when entrants remain out. In this case, entrant get 0 and incumbent gets 3, same here and same here. Then, why I am writing in this column, in fight column and accommodate column? Notice that when we are talking about normal form game, then what happen is the assumptions is all the players are moving simultaneously. In other words, when a player takes his action, then he does not know the action taken by other players. So, let us say how this game is being played in the normal form game. Just for understanding that rather than observing the entrant whether entrant is entering in the market or not, there are two players, one is entrant and another is incumbent. They are writing on a piece of paper. Their decision that of course entrant can have two actions available that is entry or out. So, that is what

an entrant can write and similarly, incumbent can write fight or accommodate. Of course, incumbent may not get to fight or accommodate if entrants write out, but the thing is that incumbent does not know what entrant is writing.

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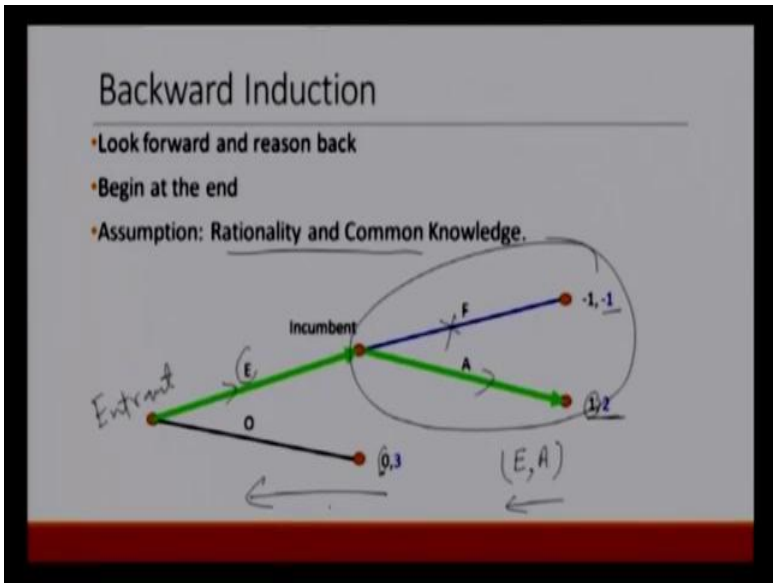

So, here these payoffs are surely decided by what entrant is taking and not what incumbent is taking. So, this would be normal form representation as here this would also try to figure out what would be the Nash equilibrium, or let us wait we will talk about it first. Let us get the new concept how we solve the extensive form game. Of course, one way to solve it is that let us represent that extensive form game in the reduced form, normal form and get what happens that we will see that there are certain problems. What we can do here is that very simple notion that we will look forward and reason back. Notice that entrant and incumbent, both are rational players. Not only they are rational players, entrant knows that incumbent is a rational player and incumbent knows that entrant is the rational player.

As incumbent is rational player, you see that if I fight I get minus 1 and if I accommodate, I get 2. 2 is definitely more than minus 1. So, of course, what would incumbent do? Incumbent would accommodate and it would not fight. If game moves to this point, it is rational for incumbent is to accommodate of course before entrant. Let us say that entrant has not taken either of the action E or O, but entrant knows that incumbent is a rational player and given an opportunity to move at this point, incumbent

is going to accommodate. So, entrant knows that if he takes the action E given would move in this direction and payoff would be 1 for entrant and 2 for incumbent. If entrant remains out, then the payoff would be 0. So, 1 is definitely greater than 0. So, what would entrant do because entrant is rational? Entrant would move in this direction and then, of course we have already figured out that incumbent would take action A rather than F. So, what is going to happen in this game? Entrant is going to take action E and incumbent is going to take action A, and the payoff for entrant is going to be 1 and payoff for incumbent is going to be 2.

Notice what did we do? We started solving game at this level. Later on we will learn, we have a specific name for this structure that we will come to later, but notice what did we use rationality and common knowledge. Not only players are rational, they know that the other players are rational. That is the input that we took. So, what is happening? First we solved here. Then, we know we said that entrant knows that if we take action, E game is moving to in this direction. So, we are looking forward, but we are reasoning back. In other words, we begin at the end. This is called backward induction technique and this is very useful in giving solution to most of the extensive form game. Later on we will learn that there are some problems should the backward induction. So, we need more elegant solution to take. We will talk about it little later.

Now, let us see what happens when we talk about Nash equilibrium? What is the best response if incumbent fights? What is the best response for entrant? Best response for the entrant is to remain out and if incumbent accommodates, then the best response is to enter. Similarly, let us look at it from best response of incumbent. If entrant enters, then the best response is accommodates and if entrant remain out, then the best response would be fight or accommodate both. So, here we get two best response of best responses. What do we get out, fight and entry, accommodate? They are two Nash equilibrium.

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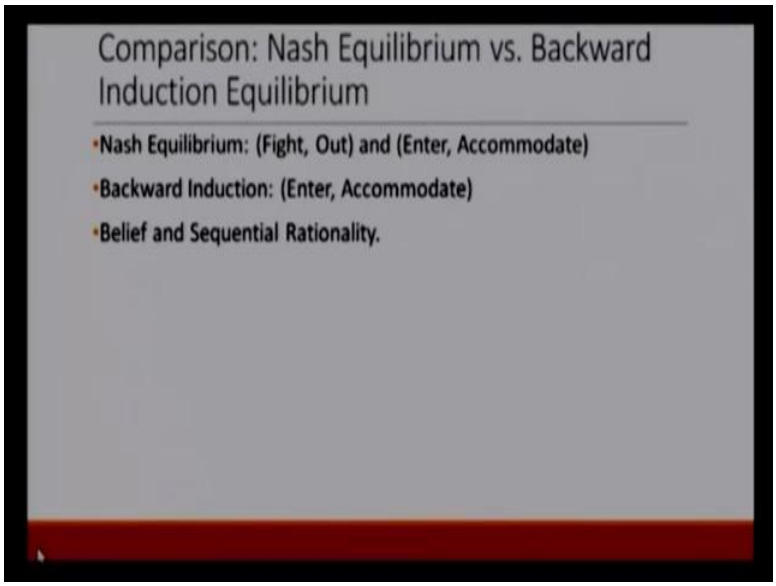

Now, let us say that what happens? So, what we have seen is, we have used two different techniques. One is backward induction technique. Backward induction gives us the outcome as entry, accommodate means entrants enters and incumbent accommodates. Second technique is the Nash equilibrium 1 that we have been using in the normal form game. What do we get is two different outcomes are possible according to this concept. One is that same as the backward induction, but Nash equilibrium also suggests second possibility that what happens that the incumbent fights and entrant remains out. So, these are two possibilities.

In one of the next module, we are going to something called sequential rationality and justify that backward induction outcome recommendation is better than Nash equilibrium recommendation, and we will talk about it in the next module.

Thank you.