GEQ1000 Asking Questions
Economics (Social Science) Segment
Video 2-2
A famous model

Game Theory

In this video you will be introduced to a famous model in economics and the social sciences.

This is one of the first models built using **Game Theory**, a branch of mathematics. The word "Theory" invokes the image of a grand overarching explanation such as "String Theory" in physics or "Evolutionary Theory" in biology, but that is not what Game Theory is about. Instead, it is more of a toolkit for building models. It is through the specific models themselves that Game Theory says things about the world.

The model

Let's meet our model, which is crafted as a game. It consists of two **players**, One and Two. Each player has two moves, or **strategies**. To Cooperate, or to Defect (that is, not cooperate). They have to choose their moves simultaneously.

Based on each person's choice of strategies, there are four possible outcomes, and four corresponding sets of **payoffs**, represented by numbers.

- If both cooperate, each gets 4
- If both defect, each gets 2
- If Player One cooperates and Player Two defects, then Player Two gets 6 while Player One gets zero.
- If Player Two cooperates and Player One defects, then Player One gets 6 while Player Two gets zero.

		Player Two: C	Player Two: D
Player One	C	4 , 4	0 , 6
Player One	D	6 , 0	2 , 2

Think of the numbers as referring to the person's satisfaction, so the bigger the number, the better off the player is. In each cell, the first number is player one's payoff, and the second number is player two's payoff.

So each player's payoff depends not only on his own choice, but also the choice of the other player. That's the idea of **Strategic Interaction**.

There is a bad outcome

Let's compare the four possible outcomes of the game, reflected in the four cells. Are there outcomes that are clearly better than others?

Now generally we may not be able to say that 4,4 is better than 0,6 or 6,0. We may not be able to say that 6,0 is better or worse than 0,6. In each comparison, someone is better off while someone else is worse off.

What we can say is that both are better off with 4,4 than with 2,2. For sure the participants do better if they both cooperate than if they both defect. 2,2 is the only outcome that we can say for sure that it is inferior to another outcome for everyone.

The bad outcome is a Nash equilibrium

What's interesting about this game is that if the players are rational and self-interested, both will defect and they will end up with 2,2! Let's see how this happens.

Suppose Player Two cooperates. Player One can either cooperate to get 4, or he can defect to get 6, so his best choice here is to defect.

Suppose Player Two defects. Player One can either cooperate to get 0, or he can also defect to get 2, so his best choice here is also to defect.

Now the players are making choices simultaneously, so Player One must decide what to do without knowing what Player Two chooses. But we have just seen that his best strategy, no matter what Player Two chooses, is to defect!

So if Player One analyses this situation rationally like we have just done, and he cares only about his own payoff, then we should expect him to defect. And since the game is symmetric, we should also expect Player Two to defect. And if both defect, we get the bad outcome!

There is another interesting and important feature about the bad outcome. The concept of **Nash equilibrium** is used to describe a situation where no player wants to change his strategy, if the strategies of other players are unchanged. A Nash equilibrium is thus a stable outcome in the sense that people will not unilaterally move from it.

In this game, (Cooperate, Cooperate) is not a Nash equilibrium because each player would rather defect, given that the other player cooperates. (Cooperate, Defect) is also not a Nash equilibrium because Player One would defect. Same with (Defect, Cooperate). So (Defect, Defect) is the only **Nash Equilibrium** in this game.

Thus, there is a dilemma within the game. Both players would be better off by cooperating. But each has the incentive to defect.

Prisoner's Dilemma

The name given to this model is Prisoner's Dilemma after the first description of the game's structure in the 1950s.

The story goes like this. Two criminal collaborators in suspicion of committing a major crime have been caught. The prosecutor doesn't quite have enough evidence to convict. So he separates the two so that they cannot communicate, and tells each prisoner that he has two alternatives, to confess the crime, or not to confess.

If they both do not confess, then the prosecutor will book them on a lesser infringement and they both get six years of jail time. If one confesses and the other does not, then the confessor gets only three years of jail time, while the non-confessor gets the maximum sentence of ten years. If both confess, they both get eight years of jail time.

We can construct a payoff matrix based on this description. The payoffs are now years in prison. The negative signs indicate that more years is bad for the prisoners.

		Prisoner Two	
		Don't Confess	Confess
Prisoner One	Don't Confess	-6 , -6	-10 , -3
	Confess	-3 , -10	-8 , -8

The payoffs are slightly different from our previous game, but the analysis gives the same conclusion. If the two prisoners are rational and self-interested, both will confess, and once again they end up in a bad outcome with eight years of prison each, when cooperating by not confessing would result in only six years of prison. You may wish to pause the video to verify this result.

So there, we have a model called Prisoner's Dilemma, and we've learned about the typical ingredients of a game. But the objective of introducing the Prisoner's Dilemma here is *not* really to teach you Game theory. To do that would require one or more entire modules. What we want to do is to illustrate how economists use models. So we will want to see how economists use the Prisoner's Dilemma. We will do that in our next video!