**W10 V5 Best Responses and Nash Equilibrium**

0:09  
Now that we've figured out what your strategies are, what your actions are, what your payouts are, and we put them in a matrix, let's figure out how to use that matrix to identify what your best responses are and an equilibrium for a given game.

0:24  
OK, so here's what the process that we're gonna follow, and I want you to exactly follow this process or not.

0:29  
OK, make sure that you're looking at a strategic situation and you can articulate what the interdependence is #2 Identify all of the actions.

0:38  
OK, put that in a matrix.

0:39  
Create your matrix and fill in the matrix with the values of the outcome for each individual, putting them in the right order.

0:48  
Now we've got to start analyzing it.

0:50  
So we're going to think about the best choice that one person can do now.

0:56  
Before, there was only one best choice because it didn't matter what anybody else is doing.

1:00  
When you have a strategic choice, it is going to be the best choice given what the other person is doing.

1:05  
So the fancy term we give that is the best response, The word response is used to highlight the fact that you're responding to what the other person is doing.

1:13  
So given what the other person is doing, this is your best choice.

1:16  
That best choice may change depending on what the other person is doing.

1:21  
OK, so first we do that for one person, we do the same thing for the other person.

1:25  
And then in the last step we put the two together to figure out equilibrium.

1:30  
Right in equilibrium.

1:31  
Here, I really want you to think about the same equilibrium as you know, idea before, which is stability.

1:37  
OK, given what one person is doing, you don't want to change anything.

1:40  
And given what I'm doing, you don't want to change anything.

1:41  
And we're kind of stable, right?

1:43  
So equilibrium is stable, except we're going to find it in a slightly different way than before.

1:48  
OK, so here's what we've done before.

1:50  
We've got the payouts of Coke or Pepsi, and we're going to use that first to figure out one person's best response.

1:58  
So let's start off with Coke.

1:59  
OK?

2:00  
Now there are two options.

2:02  
When Coke is choosing, it has to advertise or not advertise.

2:06  
But the outcome depends on what Pepsi does.

2:08  
So let's take Pepsi's choice and hold that fixed.

2:11  
So let's think about Coke's best response to when Pepsi advertised.

2:16  
So let's forget about the other option, Pepsi not advertising.

2:20  
And say if Pepsi advertises, then Coke is thinking about two million if it advertises and three million if it doesn't advertise.

2:29  
So the best outcome, The best response to Pepsi choosing to advertise, is for Coke to choose not to advertise.

2:38  
OK, then we say, OK, let's ignore this and let's look at the other one.

2:43  
If Pepsi chooses not to advertise, now, it's going to be comparing advertising to not advertising.

2:50  
One is higher than 0, and not advertising is going to be the best option.

2:56  
Now in this case that we've done with the payouts that we've choose chosen under both circumstances, where regardless of what Pepsi does, it's always better for Coke to choose not to advertise, OK, This is what we call an example of a strictly dominant strategy.

3:12  
No matter what Pepsi does, it's always strictly better because it gives them a strictly higher payoff to not advertise if you're a Coke because that gives you a higher dollar value.

3:24  
In here, we represent the best choice by just putting a small line underlining the pay off so that visually that helps us keep track of what's what.

3:33  
Let's do the same for Pepsi, OK?

3:35  
If Coke chooses to advertise, drop the other action.

3:40  
Pepsi is choosing between advertising or not, and it turns out that not advertising is better.

3:46  
OK, let's do the same thing here.

3:49  
Given that Poke Coke is going to advertise, OK, Pepsi has two choices.

3:53  
It turns out that not advertising gives it a strictly higher payoff.

3:58  
Again, Pepsi has a strictly higher payoff.

4:02  
Notice this is a very specific scenario.

4:05  
It doesn't have to be that not advertising is always better.

4:08  
But based on the payouts that we've chosen, no matter what Coke does, it is always better for Pepsi to choose not to advertise.

4:16  
So we analyse them separately and then we put them together in order to identify the equilibrium.

4:22  
So we first generated A payoff matrix.

4:24  
We've looked at Coke's payouts to figure out the best response to whatever choice of Pepsi.

4:29  
We've looked at Pepsi's payouts for every choice of Coke and figure out the best response.

4:34  
And now we're going to put them together to find the equilibrium stability.

4:40  
OK, this is when you really need to colour coded because it'll help you when you're given something like this on the exam and you have to figure it out without colours.

4:49  
So let's do it this way, OK?

4:52  
If Pepsi advertises, Coke is choosing between advertising and not, and its best response is to choose not to advertise.

4:59  
Pepsi chooses not to advertise.

5:01  
Coke is comparing advertising to not zero to 1.

5:04  
It's going to choose one.

5:07  
Same thing for Pepsi.

5:09  
If Coke chooses to advertise, Pepsi is comparing 2 to 3:00, and it's going to choose to not advertise here.

5:17  
We're going to end up here visually, when you're looking for a Nash equilibrium, you're looking for the cell where both of these have the underlines.

5:25  
Why?

5:26  
Because those are both what we call mutual best responses.

5:31  
Now, a lot of students stop here and they're like, oh, I'm just going to do it mechanically.

5:34  
I'm going to find the cell and I'm going to say that this is a Nash equilibrium.

5:39  
They're going to say that the Nash equilibrium is where Coke chooses to advertise, not to advertise, and Pepsi is going to choose also not to advertise.

5:53  
And they're gonna find it mechanically.

5:55  
But if we don't do it mechanically, what's the thought process, right?

5:59  
What makes this stable?

6:00  
So the best way to do it is to try and pick something that's maybe different, right?

6:05  
So for example, this here, clearly better for both of them, right?

6:09  
Both of them get 2 million each, whereas in the current Nash equilibrium, both of them are getting 1,000,000 each.

6:14  
So why isn't both of them advertising a Nash equilibrium?

6:19  
Well, if we think about Pepsi choosing to advertise, then for this to be a Nash equilibrium, let's do it this way.

6:27  
I'm going to write it out this way so you can kind of see it, OK.

6:30  
If Pepsi chooses to advertise, OK, then I need it for it to be stable.

6:39  
Coke also to choose to advertise, OK.

6:42  
If Pepsi is going to choose to advertise, Coke is going to compare advertise to not advertise.

6:53  
It's going to say if I stay with what I'm prescribed, which is to advertise, I'm just going to get 2,000,000.

7:00  
Whereas if I deviate and I choose something that's not advertising, I'm better off.

7:05  
OK, so advertise advertise is not going to be stable because if Pepsi's advertising, Coke doesn't want to stay with advertise, it wants to deviate and choose to not advertise.

7:15  
The same thing is going to be true for Pepsi, right?

7:18  
So Coke wants to deviate from advertising OK?

7:28  
Which means that advertise advertise is not equilibrium.

7:36  
It's not a Nash equilibrium.

7:37  
It's not stable because nobody wants to stay there.

7:40  
One person's gonna stay there, the other person wants to run away and that's not gonna be stable.

7:44  
Now on the other hand, do not advertise, do not advertise is stable cuz Pepsi's not gonna advertise.

7:49  
Coke does not want to run away to advertising because it's gonna reduce its profits from 1 to 0.

7:54  
OK, so if Pepsi is not advertising, Coke wants to stay with not advertising.

7:59  
And if Coke is going to stay with not advertising, Pepsi doesn't want to deviate and go to advertising because again, its profits are going to drop from 1 to 0.

8:06  
So it is stable given what the other person is going to do.

8:10  
And that's the keyword for a Nash equilibrium.

8:15  
It is stable given what the other person is doing.

8:19  
OK, No one wants to change given what the other person is doing.

8:23  
You need to be able to articulate this in words and not just mechanically find that underlying point in order to say that this is a Nash equilibrium.

8:30  
Here's another example thing, right?

8:33  
So this is you and your roommate deciding whether to clean the kitchen or not.

8:37  
OK, Both of you benefit from a clean kitchen.

8:41  
However, clean kitchen is costly.

8:43  
So let's say I've done all of the calculations and I've told you that this is what the payouts are, Find me the Nash equilibria.

8:49  
OK, so you'll do the same thing that we did before.

8:51  
Let's start off with your choices.

8:53  
If your roommate is going to clean the kitchen, you ignore this.

8:57  
Your best response not to clean makes sense, right?

9:01  
So I'm just going to use blue, red.

9:03  
So we make sure who we're looking at.

9:07  
What if your roommate is going to choose not to clean the kitchen?

9:11  
In that case, that's off the table.

9:13  
And you're saying, look, kitchen's really dirty, right?

9:16  
I really want it clean.

9:17  
I don't want to clean it, but I'd rather have a clean kitchen than not.

9:20  
This gives me a higher payoff of $20 compared to 10.

9:25  
That's your best response.

9:26  
Now you're going to do the same thing for your roommate.

9:29  
Your roommate is going to say if you're going to clean the kitchen, that's off the table.

9:33  
Your roommate says if you're going to clean, I'm not going to clean the kitchen.

9:41  
Similarly, if you're going to clean the kitchen, your roommate is comparing cleaning and not cleaning, and in that case you're going to end up with that as a best response.

9:56  
Now at this point, what is the Nash equilibrium?

9:59  
The Nash equilibrium here is going to be you're going to clean the kitchen and your roommate is going to not clean and you're going to say, oh, that's not fair, right?

10:20  
If you think about this, why do I have to clean it?

10:22  
I don't want to clean it because it's always me who's doing the cleaning?

10:24  
Why isn't your roommate doing it?

10:28  
Well, your roommate is going to say, I don't care so much about a clean kitchen, right?

10:31  
So even if you don't clean, it's OK Cleaning is so much of a pain that I actually get a higher payoff from having a dirty kitchen because cleaning is so much worse for me and so costly for me.

10:43  
So because your roommate is so comfortable with having a dirty kitchen and you're not, given that your roommate is not going to clean and you know they're not going to clean, you're going to say my best response is to clean.

10:55  
So suppose you decide to threaten them and you're going to say, you know what, I'm not going to clean the kitchen that's off the table.

11:00  
There's no way in hell I'm going to clean the kitchen.

11:03  
You're going to have to clean it.

11:05  
Your roommate is going to say, sure, don't clean it.

11:09  
I don't care.

11:09  
I'm still going to not clean the kitchen, in which case you're going to deviate from your promise to not clean.

11:15  
Because your best response, given that your roommate is not going to clean, is to clean the kitchen, right?

11:21  
So you can threaten whatever you want, but your threat is only credible if you actually have an incentive to follow.

11:28  
You can threaten your roommate that I'm not going to clean the kitchen, but your roommate knows that you're not going to follow through, and then you're going to end up at the equilibrium where you clean and your roommate now cleans.

11:39  
So if you want to achieve a more fair, equitable cleaning distribution of duties, you're going to have to rely on something else outside that somehow makes your roommate care about cleaning and end up in a different equilibrium.

11:51  
You're going to have to change the payouts, because with these payouts, this is the only possible outcome, OK?

12:00  
So a Nash equilibrium stability is when no one has an incentive to deviate, no one has an incentive to change their choice because doing so does not increase the payoff depending what everybody else is doing.

12:15  
Now so far the games that we've looked at, there's only one Nash equilibrium.

12:18  
There can be no Nash equilibrium.

12:20  
There can be multiple Nash equilibrium.

12:22  
So we'll look at some examples of that and many more.

12:25  
So on the problems that and some in class, OK, you need to be able to explain why this equilibrium that you've identified is stable.

12:33  
Just saying underline, underline is not enough.

12:35  
You need to explain why no one has an incentive to deviate given what the other person is doing.

12:41  
Right?

12:42  
And no one has an incentive to deviate from the prescribed strategy because doing so would lower their payouts.

12:47  
OK, that's thing in here.

12:52  
Let's look at this now with a new set of payouts.

12:54  
OK, so let's look at your things.

12:57  
Roommate.

12:59  
If he's cleaning, you're not cleaning.

13:01  
If your roommate is not cleaning, you want to clean.

13:04  
Now let's look at your roommate strategies.

13:06  
If you're going to clean, then she does not want to clean.

13:09  
If you're not going to clean now, you have a roommate, or you've incentivized something has changed, your roommate cares about cleaning and wants to clean.

13:18  
This is an example of a game where you've got two possible equilibria.

13:24  
So what you can say is we have two Nash equilibria, right?

13:27  
One where you clean and your roommate does not and then the second one where you do not and your roommate does.

13:45  
OK, So what we as economists can say there's a two possible outcomes, right?

13:50  
The kitchen will get clean.

13:51  
Just who cleans it.

13:53  
It's going to be different across these two equilibrium.

13:56  
Which one will actually happen in that case?

13:59  
We as economists cannot tell say anything more based on this information.

14:03  
Based on this information, we can just say there are two possibilities.

14:07  
Either you clean or your roommate cleans, but I cannot tell you which one will result.

14:14  
For that, you need something outside the game.

14:16  
So for example, on the first day you clean the kitchen, so therefore that's what it is for the rest of the time, right?

14:22  
Or something else that's outside of the game.

14:25  
That allows us to tell you in actuality what is going to happen.

14:29  
But your job as an economist is just to identify 2 possibilities and then you have to rely on something else outside to narrow it down further.

14:36  
But you need to be able to identify these two and explain why.

14:41  
If you're cleaning, your roommate has no incentive to deviate from do not cleaning.

14:45  
And that's makes it an equilibrium because if your roommate is not cleaning, you have no incentive to deviate from cleaning as well.

14:53  
There is a certain class of games that we call prisoner's dilemma that we're going to focus on one O 1.

14:59  
We really focus a lot of this in one, O 1 because a a lot of real life situations can be demonstrated by prisoner's dilemmas or captured by prisoner's dilemmas.

15:10  
Two, it's a really nice way to show you the unintuitive results you can get with game theory.

15:16  
OK, when unintuitive results that you have are when you introduce this idea of strategic elements.

15:21  
So I do not want you to assume that every game results in a prisoner's dilemma.

15:25  
Vice versa, if given a game, I do not want you to force it to be a Prisoner's Dilemma, because sometimes they are prisoner's dilemma and sometimes they're not Prisoner's dilemma.

15:34  
OK, Prisoner's dilemma games are games that have very specific features, so here are the specific features we need.

15:41  
One is that both players have a strictly dominant strategy, need not be the same strategy, but both players have to have a strictly dominant strategy.

15:52  
The second one is that the resulting Nash equilibrium is inefficient.

15:58  
When we have both of these characteristics, we say that the game that we're looking at is a prisoner's Dilemma.

16:04  
Now let's look at the definitions of these two things first before we can move further over the prisoner's dilemma.

16:10  
OK, strictly dominant.

16:11  
We've kind of already seen that with the Coke and Pepsi example.

16:15  
No matter what Coke does, it is always better for Pepsi to choose not to advertise, because for every choice of Coke do not advertise gives them a strictly higher payoff.

16:30  
That means that the payoff has to be at least one cent higher, but it's exactly the same.

16:35  
Then we're like, oh, it's weekly dominant, right?

16:37  
When I'm indifferent, I could do either one.

16:40  
Things get a little bit more complicated if I'm indifferent.

16:42  
And we'll explore this example on the problem set and definitely also in class.

16:46  
OK, but a strictly higher payoff for both of these, no matter what somebody else does.

16:53  
And the Coke Pepsi example is a good example of this.

16:56  
That's when we say you have a strictly dominant strategy.

16:59  
You don't have to have one.

17:02  
In fact, a lot of cases you may not have one.

17:04  
But if you do have one strategy that's always better, we call that a strictly dominant strategy.

17:09  
A prisoner's dilemma requires both players to have a strictly dominant strategy.

17:14  
That's the first thing you're checking for, to check whether game is a prisoner's dilemma or not.

17:20  
The second thing you're checking for is whether the Nash equilibrium is efficient or not.

17:25  
Here, you're going to reach all the way back into the surplus module and pull out this definition of efficiency.

17:31  
OK, efficiency says what it says.

17:33  
There's nothing that you can move or change and make one person better off, or at least one person better off without making anyone worse off.

17:42  
So for example, in the Coke Pepsi example, we ended up with a payoff of one one, right?

17:50  
The payouts in the Coke Pepsi example were one for 1,000,000 for Coke and 1,000,000 for Pepsi.

17:56  
If we moved to advertise, advertise, sorry, yeah, advertise, advertise, we would get a payoff of 2 million and 2,000,000, right?

18:10  
It makes both of them better off without making anyone worse off.

18:13  
So this is clearly more efficient, right?

18:18  
But we're not there.

18:19  
We are here.

18:20  
This is the Nash equilibrium.

18:22  
OK, Do not advertise and do not advertise.

18:28  
OK, so the Nash equilibrium is not efficient because moving to another cell would make at least one person better off without making anyone worse off.

18:36  
But we don't go there because as we've talked about advertise, advertise is not an equilibrium.

18:42  
OK, So that's what we're looking for.

18:44  
It doesn't have to make both players better off.

18:47  
It's just scanning for a cell where at least one person is better off.

18:50  
The other person can be exactly the same.

18:52  
OK, but again, it does not.

18:54  
That other cell in here does not necessarily have to be an equilibrium.

18:58  
It's just saying, oh, look, this is a possibility.

19:00  
It's not going to resolve because it's not an equilibrium, but there is a possibility for making at least one person better off without making the other person worse off.

19:09  
OK, so now let's go in here and check whether this game is a prisoner's dilemma or not.

19:13  
Let's do the same thing in here.

19:15  
OK?

19:16  
If your roommate is going to clean, you're going to not clean.

19:20  
If your roommate is not going to clean, you're not going to clean.

19:24  
You have a strictly dominant strategy of not cleaning.

19:28  
What about for your roommate?

19:30  
Let's do the same.

19:31  
If you're going to clean, your roommate does not want to clean.

19:35  
If you're going to not clean, your roommate also does not want to clean.

19:40  
So you have a strictly dominant strategy which is not cleaning.

19:44  
Your roommate has a strictly dominant strategy which is not cleaning.

19:48  
So the first condition is satisfied.

19:49  
Both of you have a strictly dominant strategy.

19:52  
What is the resulting equilibrium?

19:54  
The resulting equilibrium is do not clean, do not clean where each of you get a payoff of $10.10 dollars.

20:00  
Is this efficient?

20:02  
No, because moving here, where both of you split duties and clean the kitchen makes both of you better off, right?

20:10  
Strictly better off.

20:12  
20 dollars $20.00 for both compared to 10/10.

20:15  
So moving to clean clean would make more sense in the sense that it's more efficient.

20:21  
However, it is not an equilibrium, so you will never reach that.

20:24  
OK, so this is a prisoner's dilemma because both players have a strictly dominant strategy, which in this case is don't clean, and the resulting outcome, a resulting equilibrium, is inefficient.

20:52  
Clearly there's a better outcome for both of them, but because they're worried about strategic interactions because they're best responding, we're going to end up in a stable equilibrium where the kitchen never gets cleaned.

21:04  
OK, so here's my best advice for you.

21:06  
Please do not back out or solve or assume that that's what the answer is and try and massage it.

21:14  
Solve the game you are given.

21:16  
The real world is full of strategic situations.

21:18  
You need to be able to handle the game that you're given and not try and match patterns.

21:22  
OK, you have different possibilities.

21:25  
1 equilibrium, no equilibrium, multiple equilibrium.

21:29  
Solve the game you're given, Don't try and force it into it, OK?

21:32  
And then if you find yourself starting to bring in other things so it's not fair that my roommate doesn't clean and that's going to make me really upset, then that should be in your payouts.

21:45  
If something is relevant to your thinking, it should be in your payouts.

21:48  
If it's not in your payouts, it is not relevant, OK.

21:51  
If fairness is not something that you value, then it's not in your payouts.

21:55  
If you do care about fairness and you do feel like it's unfair if you're cleaning and your roommate is not, then that should change your payouts.

22:02  
Cuz that changes the value of the outcome of a clean kitchen for you.

22:08  
And that should be reflected in payouts that may change the game.

22:11  
Payouts are not changed, the outcome is not going to be changed.

22:16  
So again, when you're solving an equilibrium, you're looking for a payouts you're always solving.

22:22  
With the payouts.

22:22  
You're making sure you know how to read the payoff matrix.

22:25  
You're going to start by finding best responses given what the other players doing.

22:29  
This is the this choice that maximizes my payoff.

22:33  
Then you're going to do the same for the other player, and you're going to find the equilibrium where neither has an incentive to deviate given what the other person is doing.

22:41  
You're looking for mutual best responses.