

Module 2: "Static games of complete information"

Lecture 7: "Nash Equilibrium"

The Lecture Contains:

- ☰ Nash Equilibrium(NE): Definition
- ☰ NE – Examples
- ☰ Proposition relating NE & IEDS outcome

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Nash Equilibrium

- Broader concept and greater predictability
- If an outcome constitutes an NE, then none of the players would have an unilateral incentive to change the outcome
- Formal definition - In the n-player game, the strategies (s_1^*, \dots, s_n^*) constitute a NE if for each player i , s_i^* is player i 's best response to the strategies specified for the remaining "n-1" players $(s_1^*, \dots, s_{i-1}^*, s_{i+1}^*, \dots, s_n^*)$

i.e. , $U_i(s_1^*, \dots, s_{i-1}^*, s_i^*, s_{i+1}^*, \dots, s_n^*) \geq U_i(s_1^*, \dots, s_{i-1}^*, s_i, s_{i+1}^*, \dots, s_n^*)$

for every strategy s_i in S_i .

i.e.

$$s_i^* \text{ solves } \max_{s_i \in S_i} U_i(s_1^*, \dots, s_{i-1}^*, s_i, s_{i+1}^*, \dots, s_n^*)$$

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NE – Examples

		Player 2	
		NC	C
Player 1	NC	-1,-1	-9,0
	C	0,-9	-6,-6

Consider the strategy pair (NC, NC)

- Given that player 2 is playing NC, what is the best response for player 1?
 - To play C
 - player 1 gets 0 by playing C
 - player 1 gets -1 by playing NC
- Similarly given that player 1 is playing NC
 - Best response for player 2 is to play C
 - So both players have unilateral incentives to deviate
- Therefore (NC, NC) is not a NE
- **Consider the strategy pair (C, NC)**
 - Given that player 2 is playing NC
 - Best response for player 1 is to play C
 - 1st element is ok
 - Given that player 1 is playing C
 - Best response for Player 2 is to play C
 - Player 2 has an unilateral incentive to deviate
 - [C,NC] is not a NE
- **Check [NC, C] is also not a NE**
- **What about [C, C] ?**
 - Given that player 2 plays C
 - Best response for player 1 is to play C
 - Given that player 1 plays C
 - Best response for player 2 is to play C
- [C, C] is a NE.

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NE- other Example

	L	C	R
T	0, <u>4</u>	<u>4</u> , 0	5, 3
M	<u>4</u> , 0	0, <u>4</u>	5, 3
B	3, 5	3, 5	<u>6</u> , <u>6</u>

Check that only NE is (B, R)

Given that player 1 plays B, player 2's best response is R

Given that player 2 plays R, player 1's best response is B

Odd couple Example

		O		
		3	6	9
F	3	-13, -8	-1, <u>-4</u>	<u>7</u> , -4
	6	-4, <u>-1</u>	<u>4</u> , -1	4, -4
	9	<u>1</u> , 2	1, -1	1, -4

3 NE (9, 3); (6, 6); (3, 9)

NE: Another Example

- Two players: two firms in a duopoly market
- Strategies: can charge any of the three prices – high, medium or low
- That firm which charges a lower price gets the entire market
 - No profit if firm i's price > firm j's price
 - Share the market equally if both charge the same price

		Firm 2		
		High	Medium	Low
Firm 1	High	6,6	0, <u>10</u>	0,8
	Medium	<u>10</u> ,0	5,5	0, <u>8</u>
	Low	8,0	<u>8</u> ,0	<u>4</u> , <u>4</u>

NE (L,L)

- None of the players have an unilateral incentive to deviate from L given that the other plays L.

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Proposition relating NE & IEDS outcome

- Every equilibrium obtained by IEDs is a NE.
- Converse is not true
- Set of equilibria obtained by using IEDS is a subset of NE
- NE is a broader concept.

Examples:

	L	C	R
T	0,4	4,0	5,3
M	4,0	0,4	5,3
B	3,5	3,5	<u>6,6</u>

NE (B,R)

IEDS None

Recall Odd Couples example

3NE (9,3); (6,6); (3,9); IEDS (9,3)