Game Theory

8 – Games of Incomplete information: static games

Review of lecture seven

- Definitions of imperfect information
- Graphical convention for dynamic games
- Subgames, information sets, and strategies with imperfect information
- Searching NE and SPNE (from the tree to the matrix … and back to the tree)

Games and information (1)

- **Static games of complete and imperfect information**
  - Are generally represented in normal form
  - In the case of two players the game is a table (matrix) where rows and columns represent the strategies of players
  - Cells represent payoffs, known to all players
  - Solution: NE

Games and information (2)

- **Dynamic games of complete and perfect information**
  - Are generally represented through a game tree
  - Each node represents an information set, i.e. a situation where a player's choice has to be done
  - Branches represent moves
  - A strategy is a set of instructions at each node
  - All payoffs are known to all players
  - Subgames and backwards induction
  - Solution: SPNE

Games and information (3)

- **Dynamic games of complete and imperfect information**
  - Are generally represented through a game tree
  - Some players do not know the node where they are when they are asked to play, i.e., information sets are not all singleton
  - A new definition of subgames is needed
  - All payoffs are known to all players
  - A strategy is a set of instructions at each information set
  - Generally strategies are envisaged through the normal form unless backward induction is possible throughout the game (if dominated strategies are available)
  - Solution: SPNE (selecting those NE that satisfy subgame perfection)

Games and information (4)

Games studied so far assume that all players know:

- Their own and others possible moves and strategies
- Their own and others payoffs (and utility functions when utility are different from outcomes)
- When this is true we are dealing with **games of complete information**

Private information

- In real interactions people **know** their preferences **more** than others'
- For instance an individual knows better her own intentions and desires than intentions and desires of her opponents in interaction
- In the reality **no interaction exists** without the presence of private information

Asymmetric information

- In strategic models private information is the same as **asymmetric information**
- In turn that means that players do not know perfectly strategies and preferences of competitors
- It stems from this that the assumptions of complete information are violated
- To deal with real situations it is necessary to abandon the realm of **complete information**

Incomplete information

- **Strategic models of incomplete information** assume that players **may not know** payoffs and utilities of some other players
- That implies that players **may not know** which strategy other players will choose in all circumstances
- Game theory has produced strategic models that formalize this lack of knowledge

“Types” of players and the move of Nature

- John Harsanyi (1967-1968) has proposed that players may be a priori of some **types**, within a defined set of types
- At the beginning of the game a casual move by a fictitious player called **Nature** assigns the effective type to each player
- This information is given **privately** to each single player that knows exactly his/her own type

Players and types

- Each **type** of a player is characterized by its preferences, i.e., a utility function
- Each player **knows** its own type but has only a **random knowledge** of others' types
- More in details: players have **common knowledge** of the **distribution of probability** of the types
- Harsanyi's insight transforms a **game of incomplete information among players** in a **game of imperfect information among types**

Bayesian games

- Games of incomplete information introduce **beliefs** as a necessary concept to perform the analysis
- Beliefs are **probabilities** that some players assign to the event of tackling this or that type of some other players, while the distribution of probability that each player has about the types of her competitors is called her **system of beliefs** about the other players

Bayesian games

- In dynamic games it **may happen** that such probabilities **vary** during the game as a **consequence** of some previous moves of some players
- When this happens, beliefs have to be **updated** through the Bayes rule **(see later…)**
- This is why such games of incomplete information are called **Bayesian games**

Bayesian games in normal form

- Players **have** private information, and players’ actions are taken **simultaneously**
- In this case the system of beliefs of players are **not** updated during the game (and they **CANNOT** be updated actually…)
- Knowing exactly her type, each player chooses the strategy that gives her the best expected gain, **taking into account** the possible types of other players and their probability of realization
- When strategies are chosen the game ends

BNE

- In a PD, how can you control if (DEF; DEF) is a NE? Given DEF played by column player, is DEF the Best Reply for row player? And once established this, is DEF the best reply by column player to this? If the answer is “yes” to both situations, you have a NE (**best reply to each other’s strategy**)
- How can you do the same in a static game with incomplete information? You look for the same: a pair of strategies (one for each **type**, not player!) that are best reply to each other **GIVEN** a particular system of belief

Bayesian games in normal form

- **That is, a NE is reached if no player, observing the outcome, regrets her choice** (no other strategy would have given more) given the **existing** system of beliefs.
- In this case we talk of **Bayesian Nash Equilibrium** (BNE)

Example: an international contest

- An international community C
- A state K is dissatisfied with the international regime that C has established to maintain
- K has two strategies: break (b) or not break (n) the agreement
- In the same time C may decide to react somehow (r) against K's threat to the established regime, or to show indifference (i) to K's attitude
- Four possible outcomes:
- br ➔ international crisis (CR)
- bi ➔ new regime (NR)
- nr ➔ preemptive reaction (PR)
- ni ➔ status quo (SQ)

$$\begin{array}{cc|c|c|} & & \multicolumn{2}{c}{C} \\ & & r & i \\ \cline{3-4} \multirow{2}{*}{K} & b & CR & NR \\ \cline{3-4} & n & PR & SQ \\ \cline{3-4} \end{array}$$

Let us suppose K is **uncertain** on C's determination to protect the ongoing international regime

In our wording **K does not know C's type with certainty**

K knows that C may be of two types:

Prudent C : SQ > NR > CR > PR;

Determined C : PR > CR > SQ > NR

Nature informs K that the distribution of probability on C's type is

½ prudent, ½ determined

		C	
		r	i
K	b	CR	NR
	n	PR	SQ

K is a “one type player”

C may acquire two possible types: let us call them **C_p** and **C_d**

Both players have **common knowledge** of this

Moreover suppose **K** orders NR>SQ>PR>CR

What K will do against a prudent C? And what against a determined C?

A **strategy profile** of the game picks out a strategy **for all types** of players involved in the game, i.e. K, C_p, C_d

This profile can be written **(s, v, w)** where s may be (b) or (n), while v and w may be (r) or (i).

Eight possible profiles exist of this kind**: (b,r,r) (b,r,i), (b,i,r), (b,i,i), (n,r,r), (n,r,i), (n,i,r), (n,i,i)**

System of beliefs of player K about C: $p(C_p)=p$ (p=1/2 in this case)

		C	
		r	i
K	b	CR	NR
	n	PR	SQ

Determining BNE (1)

The Bayesian normal form splits **into two matrices**, as if the game was played by three players: K , C_p, C_d

		C_p	
		r	i
K	b	$u_K(br)$, $u_{Cp}(br)$	$u_K(bi)$, $u_{Cp}(bi)$
	n	$u_K(nr)$, $u_{Cp}(nr)$	$u_K(ni)$, $u_{Cp}(ni)$

		C_d	
		r	i
K	b	$u_K(br)$, $u_{Cd}(br)$	$u_K(bi)$, $u_{Cd}(bi)$
	n	$u_K(nr)$, $u_{Cd}(nr)$	$u_K(ni)$, $u_{Cd}(ni)$

To find BNE we need to give values to payoffs respecting the established orderings

Determining BNE (2)

C

		r	i
K	b	CR	NR
	n	PR	SQ

- Reminding that
- K orders NR>SQ>PR>CR
- C_p orders SQ > NR > CR > PR
- C_d orders PR > CR > SQ > NR
- let us put

$u_k(bi)=4$, $u_k(ni)=2$, $u_k(nr)=1$, $u_k(br)=0$

$u_{Cp}(ni)=4$, $u_{Cp}(bi)=2$, $u_{Cp}(br)=1$, $u_{Cp}(nr)=0$

$u_{Cd}(nr)=3$, $u_{Cd}(br)=2$, $u_{Cd}(ni)=1$, $u_{Cd}(bi)=0$

C_p

		r	i
K	b	0 , 1	4 , 2
	n	1 , 0	2 , 4

C_d

		r	i
K	b	0 , 2	4 , 0
	n	1 , 3	2 , 1

BNE conditions

		C	
		r	i
K	b	CR	NR
	n	PR	SQ

- To be an equilibrium **(s*, v*, w*)** must satisfy the following three conditions:

✓ $u_K (s^*,v^*) \cdot p + u_K (s^*,w^*) \cdot (1-p) \geq u_K (s, v^*) \cdot p + u_K (s ,w^*) \cdot (1-p)$ ***[1]***

K has only **one strategy** to play, as it may assume only one type, and its utility is **expected** because of K's uncertainty whether to tackle C_p or C_d

✓ $u_C (s^*,v^*) \geq u_C (s^*,v)$ ***[2]***

✓ $u_C (s^*,w^*) \geq u_C (s^*,w)$ ***[3]***

C plays **two strategies**, one for each type it can take, and its utility is **certain**, as C is certain about K's nature

BNE conditions

		C	
		r	i
K	b	CR	NR
	n	PR	SQ

So to have a BNE all 3 conditions should be satisfied **at the same** time!

- ✓ How to reach this situation?
- ✓ Either you apply [2] and [3], i.e., you identify for each given strategy of the one type of player the corresponding best reply of each type of the second player, before moving to [1] to understand if you have an equilibrium after all or…
- ✓ …you begin with [1] and then move to [2] and [3]

Let’s see how…

Determining BNE (3)

C_p

		r	i
K	b	0 , 1	4 , 2
	n	1 , 0	2 , 4

C_d

		r	i
K	b	0 , 2	4 , 0
	n	1 , 3	2 , 1

Among eight profiles **(b,rr), (b,ri), (b,ir), (b,ii), (n,rr), (n,ri), (n,ir), (n,ii)**…let's apply first ***[2]*** and ***[3]*** above…

- for C_p strategy r is dominated irrespective of K's strategy
- for C_d strategy i is dominated irrespective of K's strategy

➔ profiles (s,vw) with r as the second letter and with i as the third are to be eliminated

Only **(b,ir)** and **(n,ir)** survive as possible BNE for C

Determining BNE (4)

Only **(b,ir)** and **(n,ir)** survive for C

As to K, it has to calculate its payoffs playing b and playing n, and to weight both with the probability ½. That is, let's apply ***[1]*** above

C_p

		r	i
K	b	0 , 1	4 , 2
	n	1 , 0	2 , 4

C_d

		r	i
K	b	0 , 2	4 , 0
	n	1 , 3	2 , 1

$EU_K(b,ir) = 4\ ½ + 0\ ½ = 2$

$EU_K(n,ir) = 2\ ½ + 1\ ½ = 1.5$

➔ **The BNE of the game is {(b,ir)}** when $p(C_p)=½$

➔ the state K will break (b) the international regime and the international community will react following the character of its type (will be indifferent if prudent, will react if determined)

BNE

The BNE of the game is {(b,ir)} when $p(C_p)=½$

- ➔**Given this system of beliefs, no type of player regrets her choice**! The best reply to (ir) given p=1/2 is b for player K; on the other side, given b, the best reply to that of the two types of C is precisely (ir). We have a Nash Equilibrium! But a Bayesian one!
- ➔This pair of strategies is a best reply to each other ONLY for that specific system of beliefs (p=1/2)

In this case we first started with conditions [2] and [3], before applying condition [1]. Of course, we could have started with [1], and then moving to [2] and [3]. Results wont' change!

Determining BNE (5)

The BNE of the game is {(b,ir)} when $p(C_p)=½$

- The result depends on the values given to utilities and to players' beliefs (in this case only player K's beliefs about the nature of player C)
- In the example **beliefs are given** as data of the problem
- In real cases the interests involved in K's action and the **probabilities of C's reaction have to be uncovered** by empirical analysis

Determining BNE (6)

Let us call π the probability that K assigns to a prudent C, so that its belief about the event that C is determined is 1−π

Then, substituting the **now unknown** π to ½

$$EU_K(b,ir) = 4\pi + 0(1-\pi)$$

$$EU_K(n,ir) = 2\pi + (1-\pi)$$

➔ $EU_K(b,ir) > EU_K(n,ir)$ if and only if $\pi > ⅓$

➔ Breaking the international agreement is the better strategy only when the probability of encountering a prudent C is sufficiently high (more than ⅓ with the chosen payoffs), i.e., if π > ⅓ the BNE of the game is **{(b,ir)}**

➔ On the contrary, if π < ⅓ the BNE of the game is **{(n,ir)}**

Example: a dating riddle (when no dominated strategies are available)

- The scenario: A boy - Player 1; and a girl – Player 2
- Player 2, as always happens with girls, know player's 1 preferences, while player 1 is unsure (as all boys are…)
- Specifically player 1 think that with probability ½ player 2 wants to go out with him, and with probability ½ player 2 wants to avoid him….
- That is, player 1 thinks that with probability ½ he is playing the game of the left, and with probability ½ the game on the right

Player 2 (½)

		S	O
1	S	2 , 1	0 , 0
	O	0 , 0	1 , 2

Player 2 (½)

		S	O
1	S	2 , 0	0 , 2
	O	0 , 1	1 , 0

Example: a dating riddle

- Remember: for this situation, we define a BNE to be a triple of strategies, one for player 1 (just one type!) and one for each type of player 2 (two types!), with the property that:
  - The strategy of player 1 is optimal, given the strategies of the two types of player 2 (and player 1’s belief about the state)
  - The strategy of each type of player 2 is optimal, given the strategy of player 1

Example: a dating riddle

- Solving the game…let's start this time with ***[1]***
- Player 1 does not know player's 2 type, so to choose an action rationally he needs to form a belief about the action of each type. Given these beliefs and his belief about the likelihood of each type (p=1/2), he can calculate her expected payoff to each of her actions. Let's see the calculus of player 1:

	(SS)	(SO)	(OS)	(OO)
S	**2**	**1**	**1**	0
O	0	1/2	1/2	**1**

- The best reply for player 1, given (SS) is S; given (SO) is S; given (OS) is S; given (OO) is O. But what about Player 2?

Example: a dating riddle

- The best reply for player 1, given (SS) is S; given (SO) is S; given (OS) is S; given (OO) is O. But what about Player 2? Let’s apply ***[2]*** and ***[3]***!

Player 2 (½)

		S	O
1	S	2 , 1	0 , 0
	O	0 , 0	1 , 2

Player 2 (½)

		S	O
1	S	2 , 0	0 , 2
	O	0 , 1	1 , 0

- Given S played by Player 1, the best reply for the left-type of Player 2 is S; **however** for the right-type of Player 2 is O. Therefore S,SS with p=1/2 cannot be a BNE! The same is true for O,OO and S,OS
- S,SO with p=1/2, where the first component is the action of player 1 and the other component is the pair of actions of the two types of player 2, is a BNE!

Example: a dating riddle

- Of course we could also start with applying ***[2]*** and ***[3]*** and then move to ***[1]…***
- So among the 8 possible strategy profiles (S,SS), (S,OO), (S,OS), (S,SO), (O,OO), (O,SS), (O,SO), (O,OS), only (S,SO) and (O,OS) are coherent with ***[2]*** and ***[3]***

Player 2 (½)

		S	O
1	S	2 , 1	0 , 0
	O	0 , 0	1 , 2

Player 2 (½)

		S	O
1	S	2 , 0	0 , 2
	O	0 , 1	1 , 0

- Let’s apply now ***[1]***: given p=1/2, against OS, the best reply for player 1 is S not O! Therefore the only PBE is as before (of course!) S,SO with p=1/2

	(SO)	**(OS)**
S	**1**	**1**
O	1/2	1/2

Example: a dating riddle

- That is, in a BNE, player's 1 strategy is a best response to the pair of strategies of the two types of player 2…
- …while the strategy of the type of player 2 who wishes to meet player 1 is a best response in the previous left table to the strategy of player 1, and the strategy of the type of player 2 who wishes to avoid player 1 is a best response in the previous right table to the strategy of player 1

Example: a dating riddle

- Why should player 2, who knows whether she wants to meet or avoid player 1, have to plan what to do in both cases?
- **She does not have to do so**! But, as analysts, we need to consider what she would do in both cases
- Thus the equilibrium action of player 2 for each of her possible types may be interpreted as player 1’s **correct belief** about the action that each type of player 2 would take

Example: a dating riddle

- Now let’s suppose that p is not given, but must be discovered in the analysis. Is there any value of p that makes (OOS) an equilibrium strategy?

Player 2 (p)

		S	O
1	S	2 , 1	0 , 0
	O	0 , 0	1 , 2

Player 2 (1-p)

		S	O
1	S	2 , 0	0 , 2
	O	0 , 1	1 , 0

- Let’s first apply ***[2]*** and ***[3]***: as already underlined, among the 8 possible strategy profiles (S,SS), (S,OO), (S,OS), (S,SO), (O,OO), (O,SS), (O,SO), (O,OS), only (S,SO) and (O,OS) are coherent with ***[2]*** and ***[3]***

Example: a dating riddle

Player 2 (p)

		S	O
1	S	2 , 1	0 , 0
	O	0 , 0	1 , 2

Player 2 (1-p)

		S	O
1	S	2 , 0	0 , 2
	O	0 , 1	1 , 0

- Let’s then apply ***[1]***:

$EU_1(S,SO) = 2p + 0(1-p)=2p$

$EU_1(O,SO) = 0p + 1(1-p)=1-p$

$EU_1(S,SO) > EU_1(O,SO)$ if $p>1/3$

Therefore (S,SO) with $p>1/3$ is a BNE! (coherent with previous finding when $p=1/2$, remember?)

Example: a dating riddle

Player 2 (p)

		S	O
1	S	2 , 1	0 , 0
	O	0 , 0	1 , 2

Player 2 (1-p)

		S	O
1	S	2 , 0	0 , 2
	O	0 , 1	1 , 0

- Let’s then apply ***[1]***:

$EU_1(O,OS) = 1p + 0(1-p)=1p$

$EU_1(S,OS) = 0p + 2(1-p)=2-2p$

$EU_1(O,OS) > EU_1(S,OS)$ if $p>2/3$

Therefore (O,OS) with $p>2/3$ is a second BNE! With $p>2/3$ we will have therefore two BNEs: (S,SO) with $p>1/3$ and (O,OS) with $p>2/3$ (note that the second one wasn’t present in the previous situation given that particular system of beliefs: $p=1/2$)

- …and indeed when p=1, how many NE you have? Two! S,S and O,O!

Example: the dating riddle (with incomplete information on both sides)

- The scenario: A boy - Player 1; and a girl – Player 2
- Player 1 thinks that with probability p=½ player 2 wants to go out with him, and with probability (1-p)=½ player 2 wants to avoid him
- Player 2 thinks that with probability q=2/3 player 1 wants to go out with her, and with probability (1-q)=1/3 player 1 wants to avoid her (so that the girl knows that she has a greater probability of meeting a boy that wants to go out with her than otherwise, and the boy knows that! That's common knowledge…where is the surprise here???)
- Here we have 2 players but 4 types. Let's call y1 the boy that wants to go out with the girl; n1 the boy that does not want to out; similarly y2 and n2 for the 2 types of girls

Example: the dating riddle (with two sides imperfect information)

y2 (½)

y1 (2/3)		S	O
	S	2 , 1	0 , 0
	O	0 , 0	1 , 2

n2 (½)

y1 (2/3)		S	O
	S	2 , 0	0 , 2
	O	0 , 1	1 , 0

y2 (½)

n1 (1/3)		S	O
	S	0 , 1	2 , 0
	O	1 , 0	0 , 2

n2 (½)

n1 (1/3)		S	O
	S	0 , 0	2 , 2
	O	1 , 1	0 , 0

Example: the dating riddle (with incomplete information on both sides)

- How to solve this game?
- Here you should add a fourth conditions to our previous three (given that we have incomplete information on both sides…)
- Let’s write as **(s, z, v, w)** the strategy profile available for this game

BNE conditions

- To be an equilibrium **(s*, z*, v*, w*)** must satisfy the following four conditions:

✓ $u_{y1}(s^*,v^*)\cdot p + u_{y1}(s^*,w^*)\cdot(1-p) \geq u_{y1}(s, v^*)\cdot p + u_{y1}(s, w^*)\cdot(1-p)$ ***[1]***

✓ $u_{n1}(z^*,v^*)\cdot p + u_{n1}(z^*,w^*)\cdot(1-p) \geq u_{n1}(z, v^*)\cdot p + u_{n1}(z, w^*)\cdot(1-p)$ ***[2]***

Boy plays **two strategies**, one for each type he can take (i.e., Y_1 or N_1), and his utility is **expected** because of Boy's uncertainty whether to tackle Y_2 or N_2

✓ $u_{y2}(s^*,v^*)\cdot p + u_{y2}(z^*,v^*)\cdot(1-p) \geq u_{y2}(s^*, v)\cdot p + u_{y2}(z^*, v)\cdot(1-p)$ ***[3]***

✓ $u_{n2}(s^*,w^*)\cdot p + u_{n2}(z^*,w^*)\cdot(1-p) \geq u_{n2}(s^*, w)\cdot p + u_{n2}(z^*, w)\cdot(1-p)$ ***[4]***

Girl plays **two strategies**, one for each type she can take (i.e., Y_2 or N_2), and her utility is **expected** because of Girl's uncertainty whether to tackle Y_1 or N_1

Example: the dating riddle (with incomplete information on both sides)

- More in details

1. You begin with some random strategy for y1 and n1 (say SS)
2. Then you identify which is the best reply for both y2 and n2 to SS
3. Once found such best reply for y2 and n2 (say SO), you go back to step 1 to understand if SS is the best reply to the pair of strategies identified at step 2
4. If yes, you have found a BNE (i.e., SS, SO with that specific system of beliefs is a BNE)! Otherwise no…

Of course you could also begin with some random strategy for y2 and n2 and follow the same steps (but with respect to y1 and n1 in step 2)

So let's begin with **SS**

Example: a dating riddle

y2

	(SS)	(SO)	(OS)	(OO)
S	**1**	2/3	1/3	0
O	0	2/3	4/3	2

n2

	(SS)	(SO)	(OS)	(OO)
S	0	1/3	2/3	1
O	**2**	4/3	2/3	0

- Strategy 1: Given SS, the best reply for y2 is S and for n2 is O (SO)

Example: a dating riddle

y1

	(SS)	(SO)	(OS)	(OO)
S	2	**1**	1	0
O	0	0.5	0.5	1

n1

	(SS)	(SO)	(OS)	(OO)
S	0	**1**	1	2
O	1	0.5	0.5	0

- Given SO by y2n2, is SS still the best reply for y1 and n1?
- YES! Therefore you have a first BNE! (SS, SO) with p=1/2 and q=2/3

Example: a dating riddle

y2

	(SS)	(SO)	(OS)	(OO)
S	1	2/3	1/3	0
O	0	2/3	4/3	**2**

n2

	(SS)	(SO)	(OS)	(OO)
S	0	1/3	2/3	**1**
O	2	4/3	2/3	0

- Strategy 2: Given OO, the best reply for y2 is O and for n2 is S (OS)

Example: a dating riddle

y1

	(SS)	(SO)	(OS)	(OO)
S	2	1	**1**	0
O	0	0.5	0.5	1

n1

	(SS)	(SO)	(OS)	(OO)
S	0	1	**1**	2
O	1	0.5	0.5	0

- Given OS by y2n2, is OO still the best reply for y1 and n1?
- NO for both types of player 1! Therefore you do not have any BNE here!

Example: a dating riddle

y2

	(SS)	(SO)	(OS)	(OO)
S	1	2/3	1/3	0
O	0	2/3	**4/3**	2

n2

	(SS)	(SO)	(OS)	(OO)
S	0	1/3	**2/3**	1
O	2	4/3	**2/3**	0

- Strategy 3: Given OS, the best reply for y2 is O and for n2 is either S or O (SO & OO)

Example: a dating riddle

y1

	(SS)	(SO)	(OS)	(OO)
S	2	**1**	1	0
O	0	0.5	0.5	**1**

n1

	(SS)	(SO)	(OS)	(OO)
S	0	**1**	1	**2**
O	1	0.5	0.5	0

- a) Given SO by y2n2, is OS still the best reply for y1 and n1?
- NO! At least not for n1! Therefore you do not have any BNE here!
- b) Given OO by y2n2, is OS still the best reply for y1 and n1?
- YES! Therefore you have a second BNE! (OS, OO) with p=1/2 and q=2/3

Example: a dating riddle

y2

	(SS)	(SO)	(OS)	(OO)
S	1	**2/3**	1/3	0
O	0	**2/3**	4/3	2

n2

	(SS)	(SO)	(OS)	(OO)
S	0	1/3	2/3	1
O	2	**4/3**	2/3	0

- Finally, Strategy 4: Given SO, the best reply for y2 is either S or O and for n2 is O

Example: a dating riddle

y1

	(SS)	(SO)	(OS)	(OO)
S	2	**1**	1	0
O	0	0.5	0.5	**1**

n1

	(SS)	(SO)	(OS)	(OO)
S	0	**1**	1	**2**
O	1	0.5	0.5	0

- a) Given SO by y2n2, is SO still the best reply for y1 and n1?
- NO! At least not for n1! Therefore you do not have any BNE here!
- b) Given OO by y2n2, is SO still the best reply for y1 and n1?
- NO! Both for y1 as well as n1! Therefore you do not have any BNE here!

Home assignment

- A ransom game, with p=weak democracy (ready to pay the ransom); 1-p=strong democracy (not ready to pay the ransom). Let’s skip the dynamic part (it’s just an example!)

Weak Democracy (p)

		P	NP
T	K	4,3	2,2
	NK	8,-2	3,4

Strong Democracy (1-p)

		P	NP
T	K	4,2	2,3
	NK	8,-2	3,4

- Where: T (terrorist group); K=kidnap; NK=not kidnap; P=pay; NP=not pay