Intermediate public economics 3
Strategic environment

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Model of competitive market

As a descriptive model

- Can provide a fairly good prediction for the outcomes in competitive markets
- Applicable to various issues of interest, including international trade, labor market, macroeconomic policies, economic growth, valuation of environmental services

As a normative model

- Clarifies the advantages of market mechanism
- Provides practical guidance for real-world policy design
- Can be an efficient benchmark against which inefficient outcomes can be evaluated

Model of strategic environment

Strategic environment

- Essential nature of competitive market is that agents' decision making are independent of each other
- Economic and social issues, however, often involve strategic environment, where the optimal choice of one person depends on the choices of other people
- Theory of a different kind needed for predicting and analyzing the outcome in strategic environment

Game theory

- Theoretical framework for modeling strategic interaction among rational decision makers
- Game theory significantly broadens the scope of economic analysis

Example 1

Suit-and-tie or t-shirt

- Allen and Brad are insurance sales agents, competing with each other in the same district
- Wearing suit and tie makes them look credible, but feels highly uncomfortable in hot summer days
- Could instead wear a t-shirt at risk of benefiting the competitor

Questions

- Observe that the best strategy of Allen depends on the strategy of Brad (and vice versa)
- What would be the most likely outcome?
- What makes you think so?
- Is the outcome Pareto efficient?

Formalizing the idea

Game

- I: set of players
- S_i: strategy space of player $i \in I$
- $U_i : \times_{j \in I} S_j \to \mathbb{R}$: payoff function of player $i \in I$
- Notice that U_i is a function defined on $\times_{j \in I} S_j$ (not on S_i!)

Example

- Put $I := \{A, B\}$ and $S_i := \{S, T\}$ for each $i \in I$
- Define for each $i \in I$

$$U_i(s_1, s_2) := \begin{cases} 0 & \text{if } s_1 = s_2 = T \text{ for all } i \\ 3 & \text{if } s_i = S \text{ and } s_j = T \\ -5 & \text{if } s_i = T \text{ and } s_j = S \\ -2 & \text{if } s_1 = s_2 = S \text{ for all } i \end{cases} \tag{1}$$

Normal-form representation

		Player B	
		S	T
Player A	S	$U_A(S,S)$, $U_B(S,S)$	$U_A(S,T)$, $U_B(S,T)$
	T	$U_A(T,S)$, $U_B(T,S)$	$U_A(T,T)$, $U_B(T,T)$

Table 1: Payoff matrix of the game

		Player B	
		S	T
Player A	S	-2 , -2	3 , -5
	T	-5 , 3	0 , 0

Table 2: Numerical example

Example 2

Bailout and budget cut

- European Union is asking Greece for a budget cut in return for a bail-out plan
- The bail-out plan, if implemented, makes Greece better off even under a severe budget cut
- Without bail-out, Greece is likely to go bankrupt, having a catastrophic consequence to the entire Euro zone

Questions

- What would be the most likely outcome?
- What makes you think so?

Modeling the game

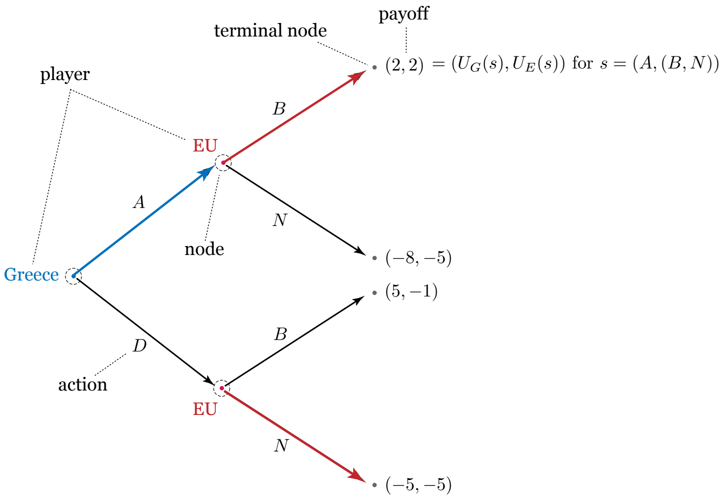
Players and strategy spaces

- $I := \{G, E\}$
- $S_G := \{A, D\}$ (accept or decline the budget-cut request)
- $S_E := \{(B, N), (N, B), (B, B), (N, N)\}$, where
  - (B, N): bail-out only when $s_G = A$
  - (N, B): bail-out only when $s_G = D$
  - (B, B): bail-out in both cases
  - (N, N): no bail-out in both cases

On the definition of strategy

- In game theory, the term 'strategy' refers to a complete contingent plan for a player in the game
- Description of actions that the player would take in each of the all possible scenarios

Extensive-form representation



Representation of games

Extensive form or normal form?

- Every game can be represented in both forms
- Easy to rewrite a game of extensive form into the same game of normal form, and vice versa
- The bail-out game, for example, may be represented in normal form with the following payoff matrix:

		EU			
		(B,B)	(B,N)	(N,B)	(N,N)
Greece	A	$2\,,2$	$2\,,2$	$-8\,,-5$	$-8\,,-5$
	D	$5\,,-1$	$-5\,,-5$	$5\,,-1$	$-5\,,-5$

Table 3: Payoff matrix of the bail-out game

Nash equilibrium

Definition

- A strategy profile $s^* = (s_i^*)_{i \in I} \in \times_{i \in I} S_i$ is called a Nash equilibrium if for each $i \in I$

$$U_i(s_i^*, s_{-i}^*) \geq U_i(s_i, s_{-i}^*) \quad \forall s_i \in S_i, \tag{2}$$

  where $s_{-i}^* := (s_j^*)_{j \in I \setminus \{i\}}$
- Every player chooses the best strategy given the strategies of the other players

What's this for?

- Our prediction of the outcome of a game must be a Nash equilibrium (otherwise not plausible)
- Minimum requirement for our prediction to be plausible
- In some cases, not sufficient for pinning down the single most likely outcome (multiple equilibria)

Guided exercise

Example 1

- Find the Nash equilibrium of the ‘suit or t-shirt’ game, the payoff matrix of which is given in Table 2
- You might want to fix a strategy of one player and then compare the payoffs of the other player
- Swap the players and repeat the same procedure

Solution

		Player B: S	T
Player A	S	$\underline{-2}\,,\,\underline{-2}$	$\underline{3}\,,\,-5$
	T	$-5\,,\,\underline{3}$	$0\,,\,0$

Table 4: Nash equilibrium of ‘suit or t-shirt’ game

Guided exercise

Example 2

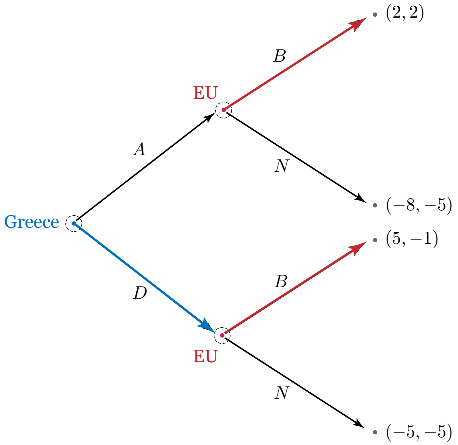
- Find Nash equilibria of the bail-out game
- You might want to solve this problem based on the normal-form representation of the game (Table 3)
- Follow exactly the same procedure as in example 1

Solution

		EU			
		(B,B)	(B,N)	(N,B)	(N,N)
Greece	A	2 , $\underline{2}$	$\underline{2}$, $\underline{2}$	-8 , -5	-8 , -5
	D	$\underline{5}$, $\underline{-1}$	-5 , -5	$\underline{5}$, $\underline{-1}$	$\underline{-5}$, -5

Table 5: Nash equilibria of bail-out game

Which one is the most plausible?



Subgame perfection

Narrowing down the equilibrium

- In Nash equilibrium, actions off the equilibrium path are not required to be the best response
- Observe that two of the Nash-equilibrium strategies above include empty threats
- Players, if rational enough, would find such strategy incredible

Subgame perfect Nash equilibrium

- For a Nash eqm to be plausible, some additional requirement needed
- At every decision node (i.e., in every subgame), players must have no incentive to deviate from the strategy
- Nash equilibrium satisfying this condition is said to be subgame perfect

Subgame perfect Nash equilibrium