Speler 1 \ Speler 2	L	R
B	3, 3	0, 5
O	5, 0	1, 1

Economie: een serieus spel.

Speltheoretische begrippen met economische toepassingen.

Markt & Strategie—Academiejaar 2015-2016

www.uantwerpen.be/Jan-Bouckaert jan.bouckaert@uantwerpen.be Twitter: @JanBouckaert

UAntwerpen—Departement Algemene Economie

Open lesdagen februari 2016

Economisch Beleid aan UAntwerpen

- Brede opleiding over Algemene Economie
- Thema’s:
  - Macro-economie: Eurozone, overheidsfinanciën, …
  - Micro-economie: gezondheid, milieu, concurrentie, regelgeving,…
- Economisch perspectief over
  - Maatschappelijke thema’s
  - Bedrijfskundige onderwerpen
  - …
- Bruikbaarheid:
  - Ideale basis voor veel specialisaties
  - Professionele uitwegen: (non)profit, privé en overheid, binnen- en buitenland

programma

DEEL 1: SPELTHEORIE

1. 12 februari: speltheorie I
   - Statische en Dynamische spelen met Complete Informatie
2. 19 februari: Oefeningen
3. 26 februari: Oefeningen
4. 4 maart: speltheorie II
   - Statische en Dynamische Spelen met Incomplete Informatie

programma

DEEL 2: MARKT EN STRATEGIE

1. 11 maart: verticale integratie
2. 18 maart: productdifferentiatie
3. 25 maart: prijsdiscriminatie
4. 1 april: verticale relaties
5. 22 april: vrije toegang
6. 29 april: tweezijdige markten
7. 13&20 mei: vragensessie

programma

DEEL 1: SPELTHEORIE

1. 12 februari: speltheorie I
   - Statische en Dynamische spelen met Complete Informatie

A “game”

- a *stylized* description or model
- depicting situations of *strategic behavior*
- where the *payoff* for one agent depends on its own actions
- *as well as* on the actions of *other agents*

“Game” and industrial organization

- Industry with a few “players”
- Every firm’s payoff depends on e.g.
  - the own price set

  and
  - the price set by the other firms!
- Firms are therefore operating in a world of strategic behavior: a “game”!

Games and strategies

The optimal strategy of

- a specific player depends on the expectations about the rational behavior of the other players
- the other players also depend on the expectations about the rational behavior of this specific player
- this specific player takes into account what the others expect him to play and so do the other players…*ad infinitum*

Games and strategies

- If the strategic interaction evolves over a number of periods, each player takes into account that her actions today will have an impact on the other players' conjectures and actions in the future!
- Summary: pay-off interdependency introduces a host of possibilities for strategic behavior—this is the subject of game theory!

Game theory: basic concepts

- Game theory

  is essential to understand the competitive behavior between a small number of firms.

- A (optimal) strategy
  - is the (best) action plan representing the player's actions for every possible contingency.
  - depends on the actions other players can take
- Pay-offs are dependent on every combination of actions such that strategic behavior becomes optimal.
- A "game" is a strategic situation.

Game theory: basic concepts

A game

- consists of
  - players
  - possible actions each player can take
  - pay-offs
- can be classified as

		information	
		complete	incomplete
timing	static	static, complete information game	static, incomplete information game
	dynamic	dynamic, complete information game	dynamic, incomplete information game

Twittergeroddel ontaardt in bankrun in Letland

Een stroom valse Twittergeruchten over de wankele gezondheid van de Zweedse Swedbank heeft het voorbije weekend in Letland geleid tot een ware bankrun. Klanten gingen massaal hun geld weghalen bij de lokale Swedbank-dochter. Dat leverde taferelen op die in Europa al bijna vijf jaar niet te zien waren. Toen stonden duizenden Britten in de rij om hun rekeningen bij de noodlijdende bank Northern Rock leeg te halen.

12 december 2011
(foto 13 december 2011, DT)

Dominant strategy

- Dominant strategy of a rational player
  - does not assume anything about
    - the rationality of the other players
    - the “pay-offs” of the other players
  - tells what a player chooses (is “informative”)
  - is a “robust” strategy
  - is a very demanding property to be a player’s optimal strategy: few games have a dominant strategy

the "prisoner's dilemma" game

Figure 3
The Prisoners' Dilemma

		Player 2	
		L_2	R_2
Player 1	L_1	1, 1	5, 0
	R_1	0, 5	4, 4

Dominant strategy, the normal form, and the Prisoner's dilemma

- The prisoner's dilemma can easily be solved using the concept of a "dominant strategy"
- Both players strictly prefer one strategy to the other independent of the other player's choice:
  - player 1 strictly prefers L_1 to R_1
  - player 2 strictly prefers L_2 to R_2

The Prisoner's dilemma

- depicts many economic settings, like e.g. price competition
  - when all firms set high prices, the industry as a whole benefits from it (*common* interest)
  - every individual firm has a dominant strategy to deviate towards a lower price whatever the other firms do (*individual* interest)
- Conflict between individual incentives and joint incentives!
  - (L_1, L_2) results in joint payoff of 1+
  - (L_1, R_2) and (L_2, R_1) result in joint payoff of 5+0
  - (R_1, R_2) results in joint payoff of 4+4
  - individual interest in playing
    - L_1 for player 1 *whatever* player 2 chooses
    - L_2 for player 2 *whatever* player 1 chooses

static games with complete information

We begin with two-player, simultaneous-move games. (Everything we do for two-player games extends easily to three or more players; we consider sequential-move games below.) The timing of such a game is as follows:

1) Player 1 chooses an action a_1 from a set of feasible actions A_1. Simultaneously, player 2 chooses an action a_2 from a set of feasible actions A_2.

2) After the players choose their actions, they receive payoffs: $u_1(a_1, a_2)$ to player 1 and $u_2(a_1, a_2)$ to player 2.

static games with complete information

Figure 1
An Example of Iterated Elimination of Dominated Strategies

		Player 2		
		Left	Middle	Right
Player 1	Up	1, 0	1, 2	0, 1
	Down	0, 3	0, 1	2, 0

static games with complete information

how (not) to play this game?

- "iterated elimination of dominated strategies"
  - if player 2 (P2) is, according to player 1 (P1), is rational, "Right" should *not* be played
  - P1, knowing that P2's only rational choice is Left or Middle, rationally prefers Up to Down
  - if P2 realizes that P1 is rational, and P2 knows that P1 knows that P2 is rational, P2 knows P1 will choose Up, wherefrom P2 regards Left to be *dominated* by Middle.

static games with complete information

- drawbacks
  - assumes knowledge about the *other* player's rationality
  - has *imprecise* predictive power

Figure 2

A Game without Dominated Strategies to be Eliminated

	L	C	R
T	0, 4	4, 0	5, 3
M	4, 0	0, 4	5, 3
B	3, 5	3, 5	6, 6

Iterated elimination of dominated strategies

- assumes a lot of “rationality”!
- Every player assumes that
    - the other players are rational
    - they know that you are rational
    - they know that you know that the others are rational
    - …
- Rationality is said to be “common knowledge”

Iterated elimination of dominated strategies

A "risky" game:

Kathy

Ronny

	L	R
T	1, 0	1, 1
B	-100, 0	2, 1

Iterated elimination of dominated strategies

- Our “risky” game shows that
  - a small probability of irrationality can have large consequences for player 1’s payoff.
  - a game with a dominated strategy is very sensitive to the assumption of common knowledge about each other’s rationality.
- What of there is no dominated or dominant strategy?

static games with complete information: The Nash equilibrium

- Suppose our theory to provide a solution to a game yields a unique prediction
- What properties should this theory have?
  - Each player should be willing to choose the strategy the theory predicts the agent will play
  - Put differently: each player's predicted strategy must be that player's *best response* to the predicted strategies of all players
  - Such a collection of predicted strategies for all players is referred to as *strategically stable* or *self-enforcing* because no single player wants to deviate from his or her predicted strategy

static games with complete information

The Nash equilibrium satisfies "mutual best-responsiveness"

Formally, in the two-player, simultaneous-move game described above, the actions (a_1^*, a_2^*) are a Nash equilibrium if a_1^* is a best response for player 1 to a_2^*, and a_2^* is a best response for player 2 to a_1^*. That is, a_1^* must satisfy $u_1(a_1^*, a_2^*) \geq u_1(a_1, a_2^*)$ for every a_1 in A_1, and a_2^* must satisfy $u_2(a_1^*, a_2^*) \geq u_2(a_1^*, a_2)$ for every a_2 in A_2.

static games with complete information The Nash equilibrium

Figure 1

An Example of Iterated Elimination of Dominated Strategies

		Player 2		
		Left	Middle	Right
Player 1	Up	1, 0	1, 2	0, 1
	Down	0, 3	0, 1	2, 0

static games with complete information
The Nash equilibrium

Figure 2

A Game without Dominated Strategies to be Eliminated

	L	C	R
T	0, 4	4, 0	5, 3
M	4, 0	0, 4	5, 3
B	3, 5	3, 5	6, 6

static games with complete information

example of a unique Nash equilibrium

Figure 3

The Prisoners' Dilemma

Player 2

Player 1		L_2	R_2
	L_1	1, 1	5, 0
	R_1	0, 5	4, 4

static games with complete information

example of more than one Nash equilibrium

Figure 4
The Dating Game

		Pat: Red	Pat: White
Chris	Steak	2, 1	0, 0
Chris	Chicken	0, 0	1, 2

static games with complete information

example of no Nash equilibrium (in pure strategies)

Figure 5
Matching Pennies

		Player 2	
		Heads	Tails
Player 1	Heads	−1, 1	1, −1
	Tails	1, −1	−1, 1

static games with complete information

example of no Nash equilibrium (in pure strategies)

- Any game where players outguess each other has no Nash equilibrium in pure strategies as defined above
- A mixed strategy is a strategy that makes use of a probability distribution over some or all of the player's pure strategies
- Extension of the Nash equilibrium to allow for mixed strategies results in

  "any game with a finite number of players, each of whom has a finite number of pure strategies, has a Nash equilibrium (possibly involving mixed strategies)". (Nash, J., 1950, Equilibrium Points in n-Person Games, *Proceedings of the National Academy of Sciences*, 36, 48-9).

A beautiful Mind

https://www.youtube.com/watch?v=2d_dtTZQyUM

Dynamic games with complete information

A simple 2-person game

1) Player 1 chooses an action a_1 from a set of feasible actions A_1.

2) Player 2 observes 1's choice and then chooses an action a_2 from a set of feasible actions A_2.

3) After the players choose their actions, they receive payoffs: $u_1(a_1, a_2)$ to player 1 and $u_2(a_1, a_2)$ to player 2.

Dynamic games with complete information

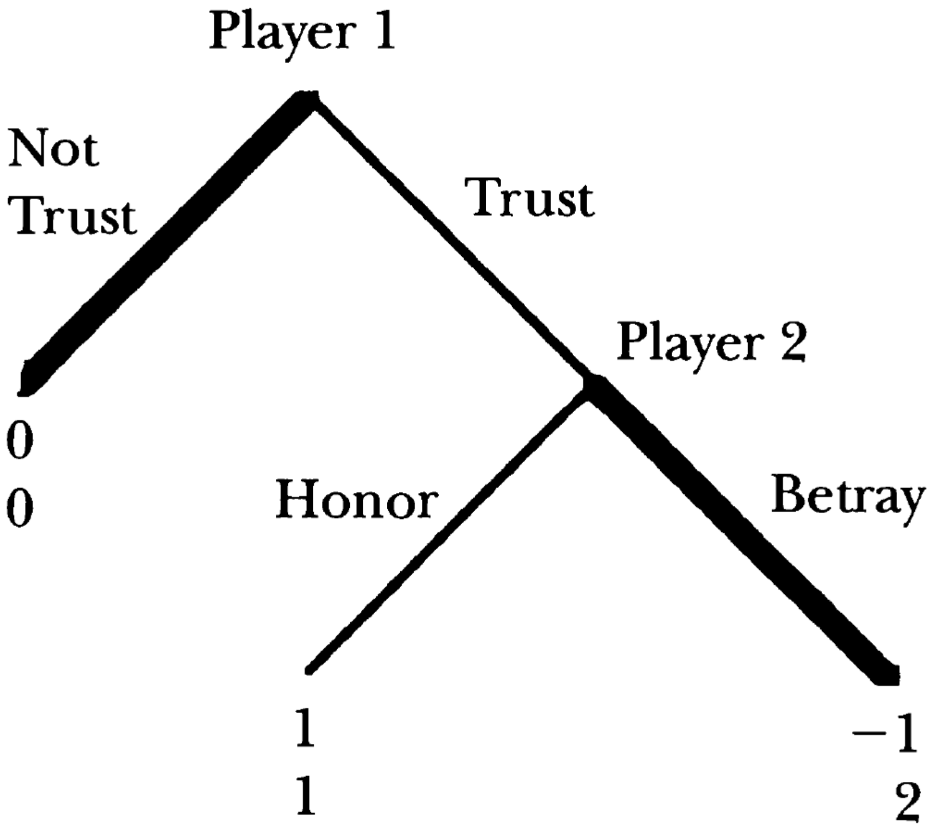
A simple 2-person game

- Examples:
  - The dictator game
    - player 1 (the dictator) divides €100 between *him*self and some other player 2
  - The (ultimatum) bargaining game
    - P1 divides €100 between himself and some other P2 who may accept or refuse. In the latter event, no one receives something…
  - The trust game
    - P1 either trusts or does not trust P2
    - If P1 does not trust P2, the game ends: P1 puts an end to the relationship with P2
    - If P1 chooses to trust P2, P2 chooses to Honor or to Betray P1's trust

Dynamic games with complete information

backward induction

- If P2 gets to move, then “Betray” results in 2 while “Honor” only leaves him with 1
- Anticipating this, P1 prefers not to trust P2

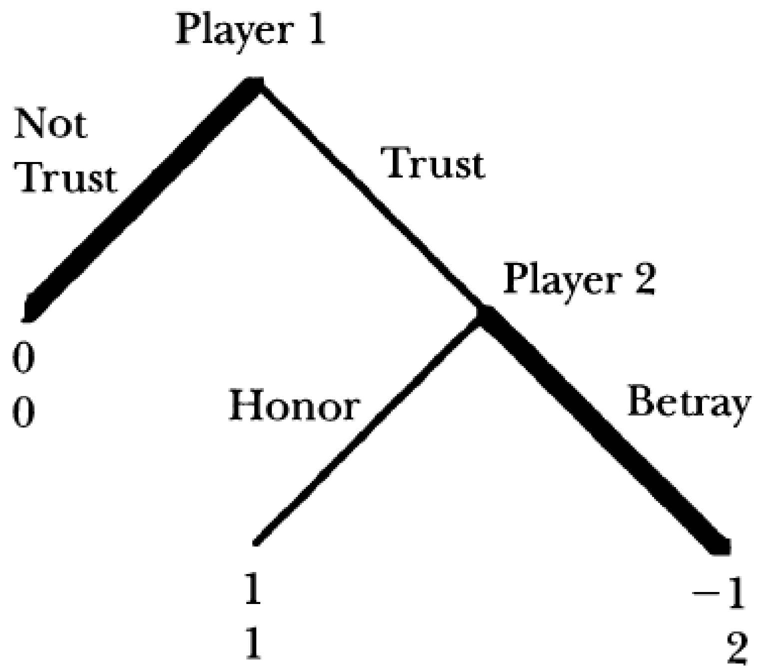


Dynamic games with complete information

Extensive form and normal form game representations

Figure 6

The Trust Game



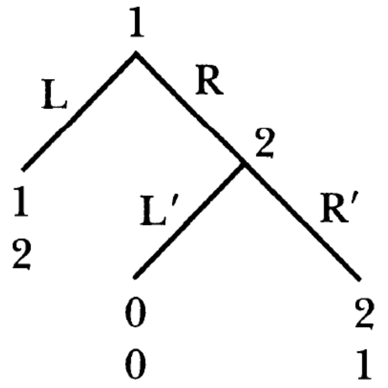
		Player 2	
		Honor	Betray
Player 1	Trust	1, 1	−1, 2
	Not Trust	0, 0	0, 0

Dynamic games with complete information

credibility of threats and emptiness of promises

- Some games have several Nash equilibria:
  - credible threats/promises based
  - no-credible threats/promises based

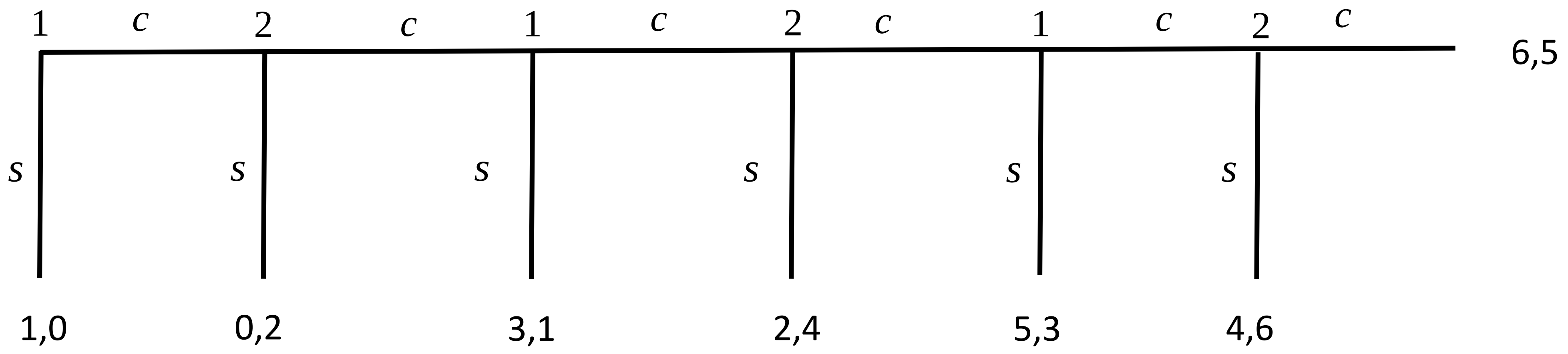
Figure 7
A Game that Relies on a Noncredible Threat



	L′	R′
L	1, 2	1, 2
R	0, 0	2, 1

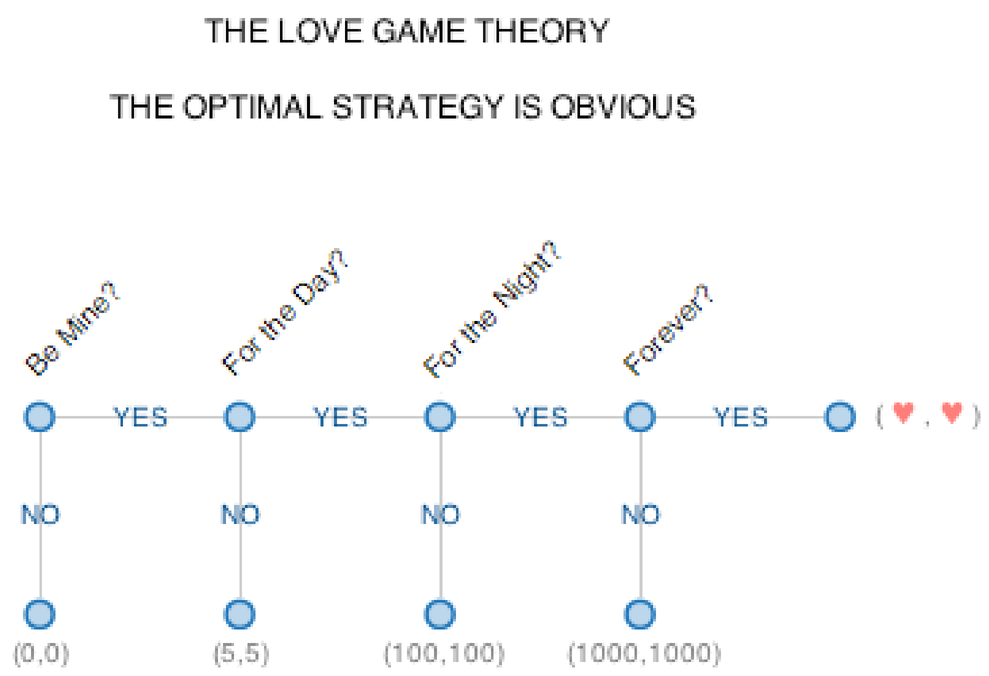
Dynamic games with complete information

the centipede game



Dynamic games with complete information

the centipede Valentine love game



Dynamic games with complete information

Subgame Perfect Nash Equilibrium (SPNE)

- Refinement of Nash Equilibrium (NE)
  - Every SPNE is a NE
  - Not every NE is a SPNE
- SPNE rules out NE that rely on non-credible threats
- A unique solution to a game-theoretic problem must satisfy Nash's mutual best-response requirement
- In dynamic games, mutual best-responsiveness should also apply to parts of the game, i.e. subgames, that remain to be played
- E.g. part of the Trust game P2 plays; bargaining game with P1's choice already taken; …

Dynamic games with complete information

dynamic games with interaction over time

- Threats and promises over future behavior may influence current behavior
- E.g. Trust game repeated over time
- Players follow the “grim-trigger” or “Nash-reversion” strategy:

> *Player 1:* In the first period, play Trust. Thereafter, if all moves in all previous periods have been Trust and Honor, play Trust; otherwise, play Not Trust.
>
> *Player 2:* If given the move this period, play Honor if all moves in all previous periods have been Trust and Honor; otherwise, play Betray.

Dynamic games with complete information

dynamic games with interaction over time

- One-shot Trust game version results in (No Trust, Betray) or (0,0)
- The “trigger” strategy uses this outcome as punishment (P):
  - Repeated game collapses to the one-shot version if cooperation is not honored
  - Per-period Returns from cooperation (C) are (1,1)
  - Cooperation is threatened by defection (D) resulting in an immediate and one-period payoff (-1,2)
  - P2 cooperates if cooperation payoffs

$$\left(1+\frac{1}{r}\right)C \geq D+\frac{1}{r}P \text{ or } r \leq \frac{C-P}{D-C}$$

with r a measure of players’ patience

Dynamic games with complete information

dynamic games with interaction over time

- P1 only receives 0 by not cooperating and 0 thereafter…
- If P2 finds it optimal to Honor, so will P1 be willing to Trust…

- General insight:
  - Cooperation is prone to Defection
  - Defection can be met with Punishment
  - Potential defectors weigh the discounted
    - long-run benefits from continued cooperation

    against
    - the short-run benefits from defection and the long-run costs from Punishment
  - Sufficient patience may result in cooperation in a repeated game that was unfeasible in the one-shot game…

references

this presentation is based on and extensively made us of

"Gibbons, R., 1997, An Introduction to applicable game theory, Journal of economic Perspectives, Winter, vol. 11,1, 127-149."