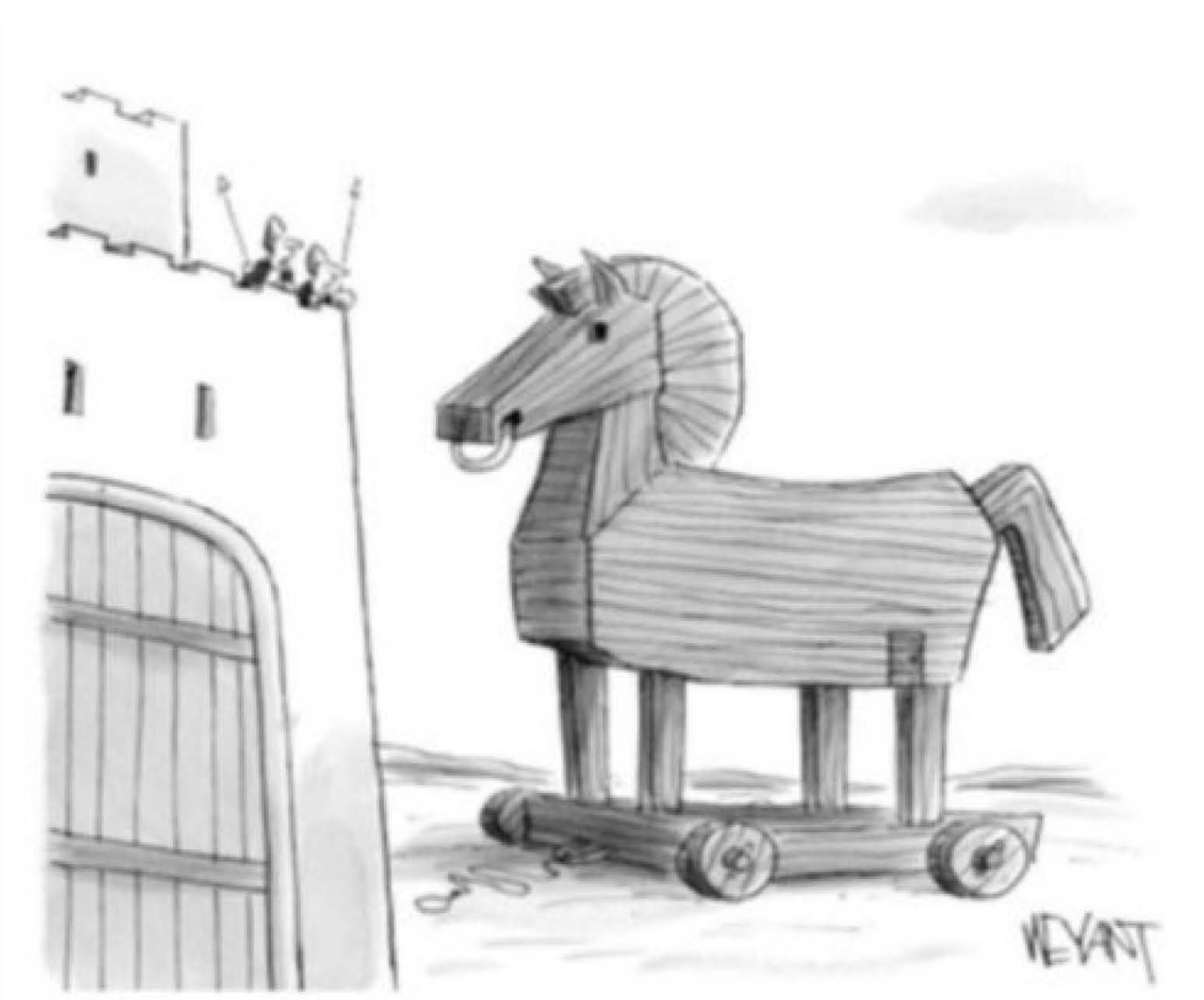
University of California – Berkeley
Department of Economics
Game Theory in the Social Sciences
(ECON C110 | POLSCI C135)
Fall 2023

Lecture I
Introduction

Aug 24, 2023

Guys, it's time for some game theory…



What’s game theory?

Game theory

- Game theory is about what happens when decision makers (spouses, workers, managers, presidents) interact.

- In the past fifty years, game theory has gradually became a standard language in economics.

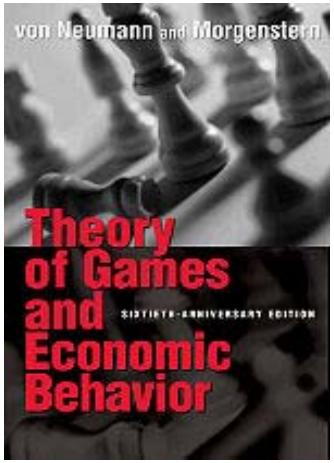
- The power of game theory is its generality and (mathematical) precision.

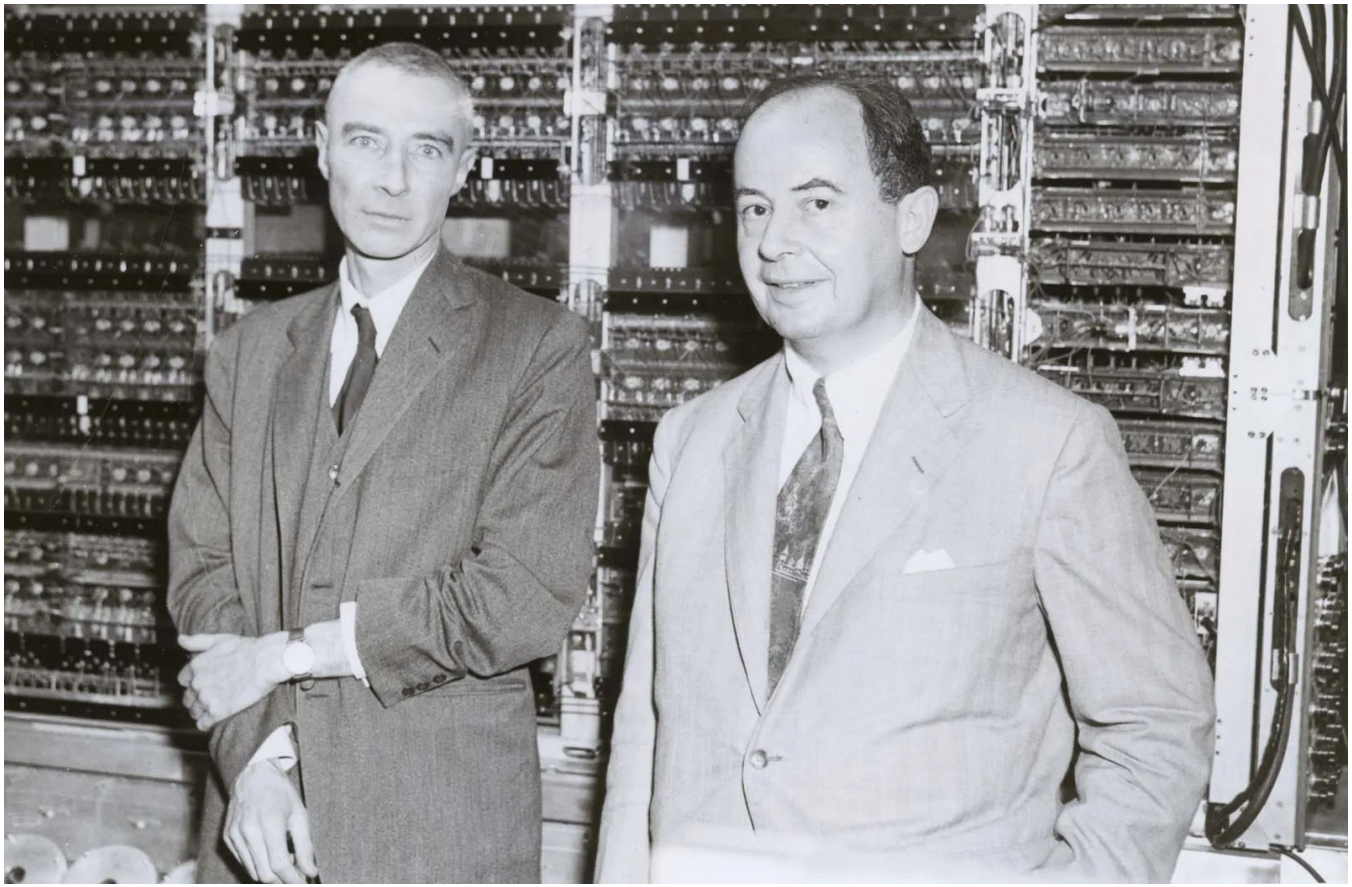
- Because game theory is rich and crisp, it could unify many parts of social science.

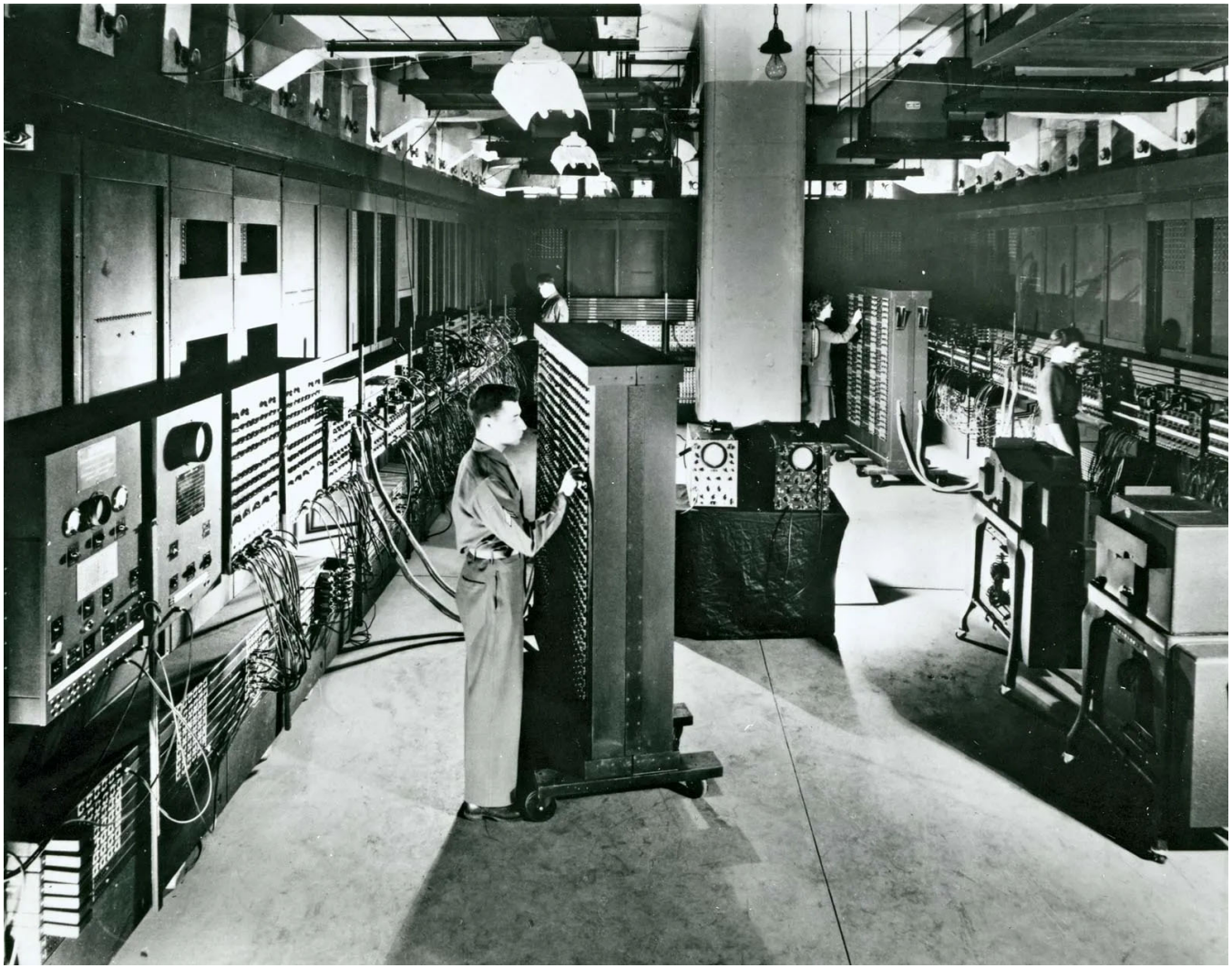
- The spread of game theory outside of economics has suffered because of the misconception that it requires a lot of fancy math.

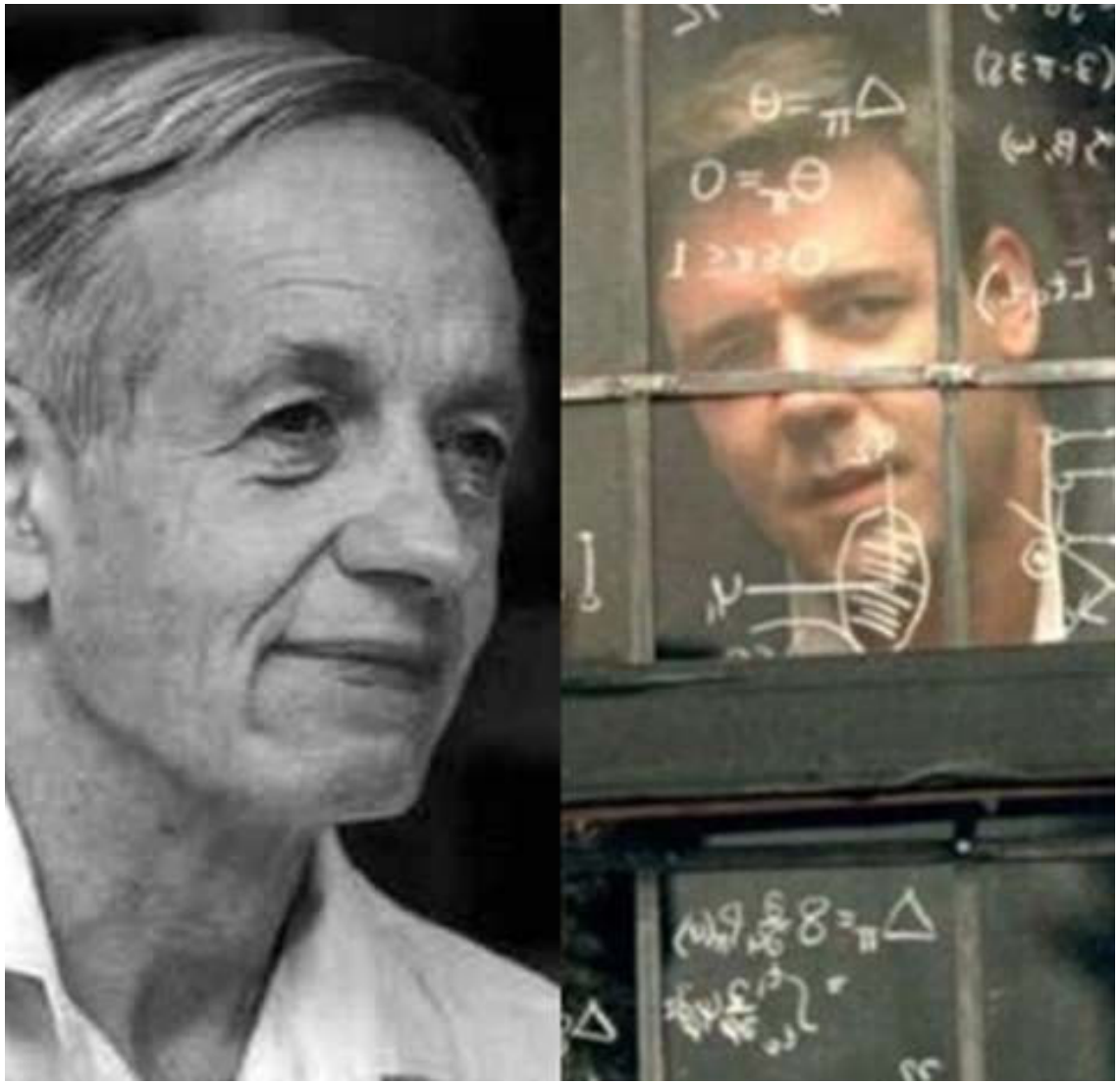
- Game theory is also a natural tool for understanding complex social and economic phenomena in the real world.

The paternity of game theory









What is game theory good for?

Q Is game theory meant to predict what decision makers do, to give them advice, or what?

A The tools of analytical game theory are used to predict, postdict (explain), and prescribe.

Remember: even if game theory is not always accurate, descriptive failure is prescriptive opportunity!

As Milton Friedman said famously observed "theories do not have to be realistic to be useful." A theory can be *useful* in three ways:

A. descriptive (how people actually choose)

B. prescriptive (as a practical aid to choice)

C. normative (how people ought to choose)

Aumann (1987):

> "*Game theory is a sort of umbrella or 'unified field' theory for the rational side of social science, where 'social' is interpreted broadly, to include human as well as non-human players (computers, animals, plants).*"

Adam Brandenburger:

> *There is nothing so practical as a good [game] theory. A good theory confirms the conventional wisdom that "less is more." A good theory does less because it does not give answers. At the same time, it does a lot more because it helps people organize what they know and uncover what they do not know. A good theory gives people the tools to discover what is best for them.*

The New York Times Magazine

FEATURE

How Data (and Some Breathtaking Soccer) Brought Liverpool to the Cusp of Glory

The club is finishing a phenomenal season — thanks in part to an unrivaled reliance on analytics.

Farhan Zaidi, the General Manager of the SF Giants and previously the LA Dodgers (PHD in economics from UC Berkeley), and the person Billy Beane called “absolutely brilliant.”

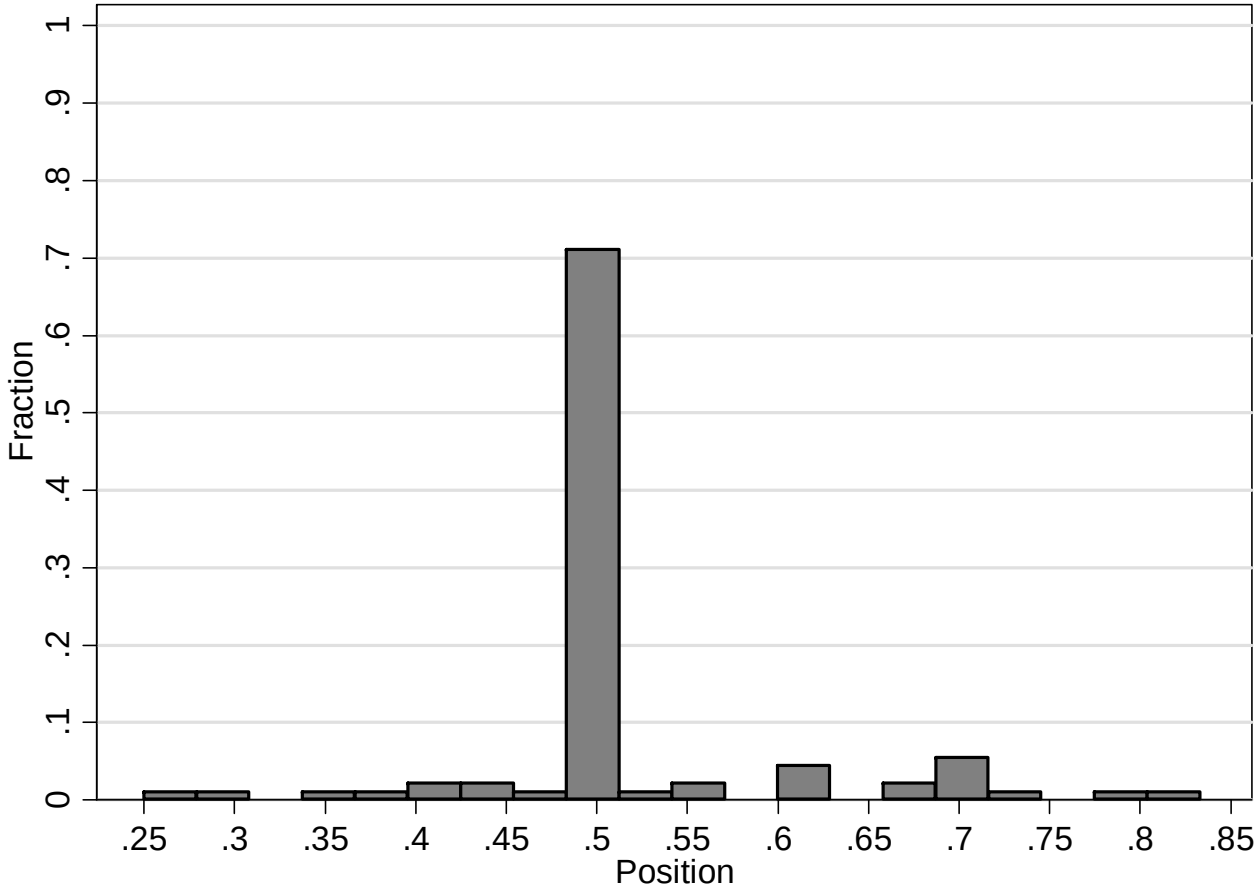
Four ‘simple’ games

Four examples

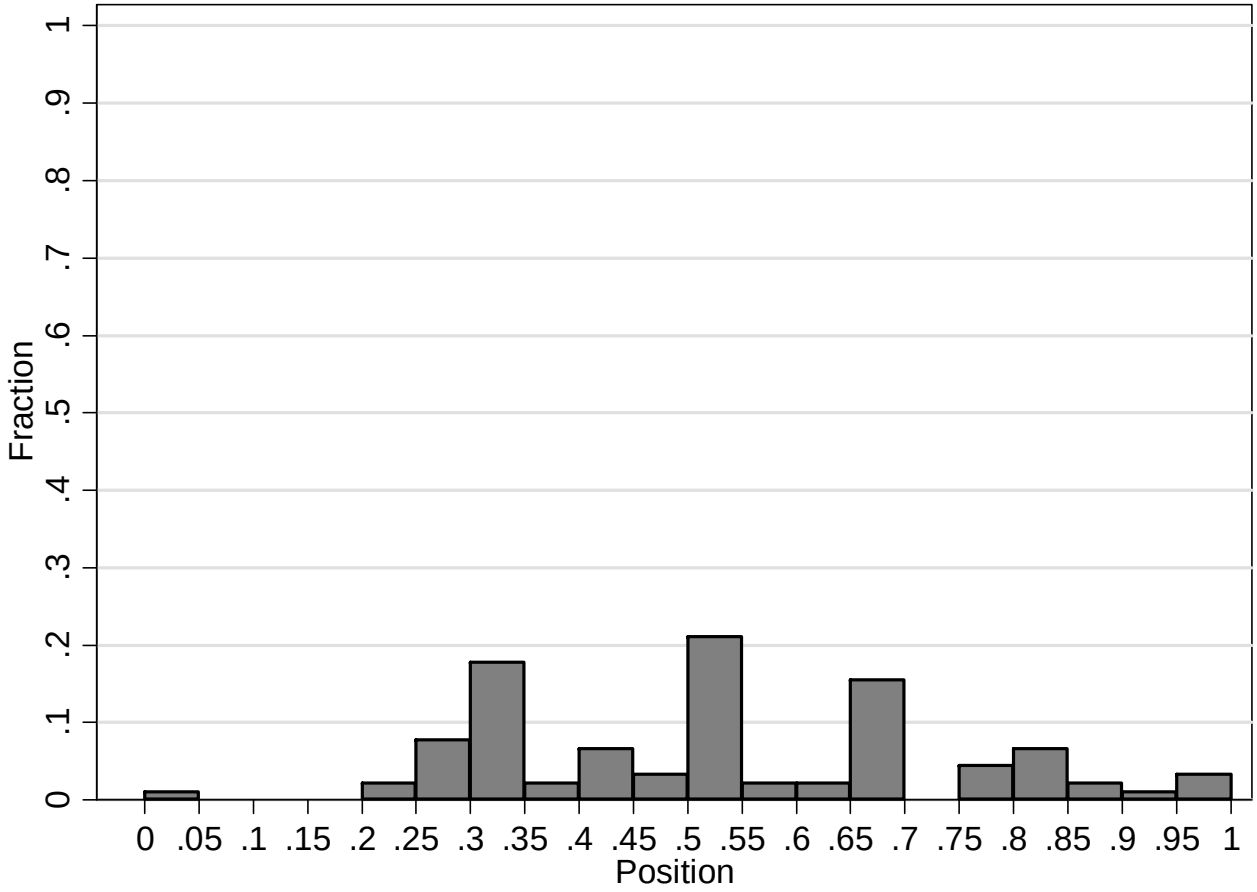
Example I: Hotelling's electoral competition game

- There are two candidates and a continuum of voters, each with a favorite position on the interval $[0, 1]$.
- Each voter's distaste for any position is given by the distance between the position and her favorite position.
- A candidate attracts the votes off all citizens whose favorite positions are closer to her position.

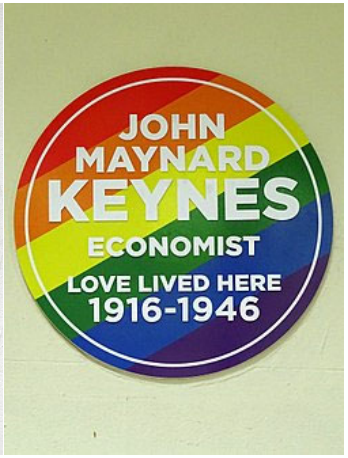
Hotelling with two candidates class experiment



Hotelling with three candidates class experiment



John Maynard Keynes
1883-1946



Example II: Keynes's beauty contest game

- Simultaneously, everyone choose a number (integer) in the interval $[0, 100]$.
- The person whose number is closest to $2/3$ of the average number wins a fixed prize.

John Maynard Keynes (1936):

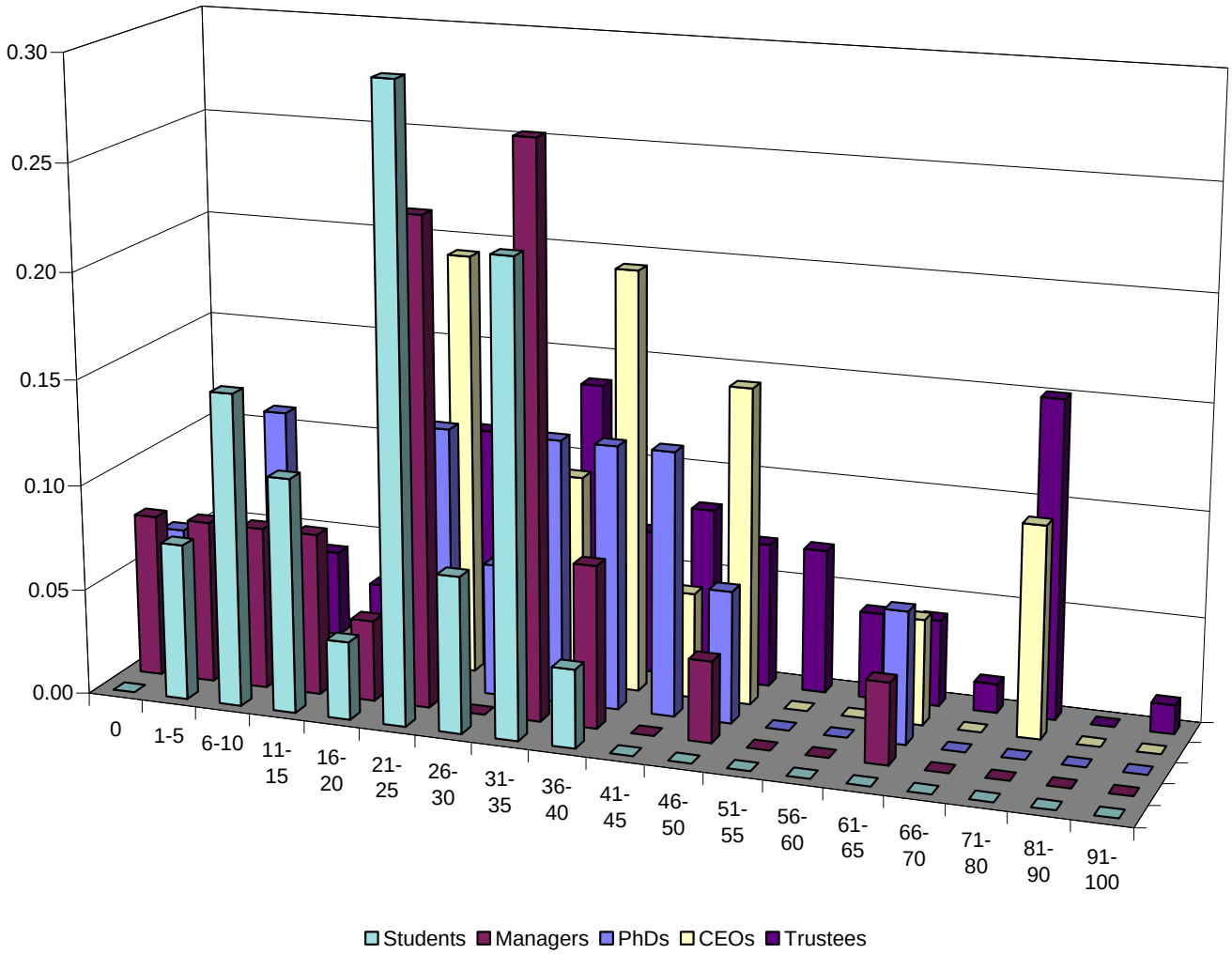
> "*It is not a case of choosing those [faces] that, to the best of one's judgment, are really the prettiest, nor even those that average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practice the fourth, fifth and higher degrees.*"

$\Longrightarrow$ self-fulfilling price bubbles!

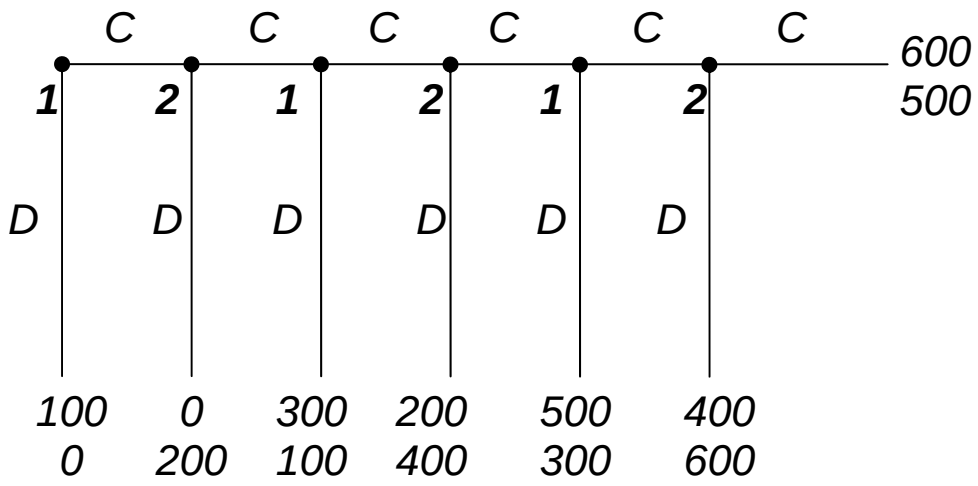
Beauty contest results

	Portfolio Managers	Economics PhDs	CEOs	Caltech students	Caltech trustees
Mean	24.3	27.4	37.8	21.9	42.6
Median	24.4	30.0	36.5	23.0	40.0
Fraction choosing zero	7.7%	12.5%	10.0%	7.4%	2.7%

	Germany	Singapore	UCLA	Wharton	High school (US)
Mean	36.7	46.1	42.3	37.9	32.4
Median	33.0	50.0	40.5	35.0	28.0
Fraction choosing zero	3.0%	2.0%	0.0%	0.0%	3.8%


0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-80
81-90
91-100
Students
Managers
PhDs
CEOs
Trustees

Example III: the centipede game (graphically resembles a centipede insect)



The centipede game class experiment

Down	*0.311*
Continue, Down	*0.311*
Continue, Continue, Down	*0.267*
Continue, Continue, Continue	*0.111*

Eye movements can tell us a lot about how people play this game (and others).

Example IV: auctions

From Babylonia to eBay, auctioning has a very long history.

Babylon:

- women at marriageable age.

Athens, Rome, and medieval Europe:

- rights to collect taxes, dispose of confiscated property, lease of land and mines,

and many more...

The word "auction" comes from the Latin *augere*, meaning "to increase."

The earliest use of the English word "auction" given by the *Oxford English Dictionary* dates from 1595 and concerns an auction "when will be sold Slaves, household goods, etc."

In this era, the auctioneer lit a short candle and bids were valid only if made before the flame went out – Samuel Pepys (1633-1703) –

- Auctions, broadly defined, are used to allocate significant economics resources.

  Examples: works of art, government bonds, offshore tracts for oil exploration, radio spectrum, and more.

- Auctions take many forms. A game-theoretic framework enables to understand the consequences of various auction designs.

- Game theory can suggest the design likely to be most effective, and the one likely to raise the most revenues.

Types of auctions

Sequential / simultaneous

Bids may be called out sequentially or may be submitted simultaneously in sealed envelopes:

- English (or oral) – the seller actively solicits progressively higher bids and the item is soled to the highest bidder.
- Dutch – the seller begins by offering units at a "high" price and reduces it until all units are soled.
- Sealed-bid – all bids are made simultaneously, and the item is sold to the highest bidder.

First-price / second-price

The price paid may be the highest bid or some other price:

- First-price – the bidder who submits the highest bid wins and pay a price equal to her bid.

- Second-prices – the bidder who submits the highest bid wins and pay a price equal to the second highest bid.

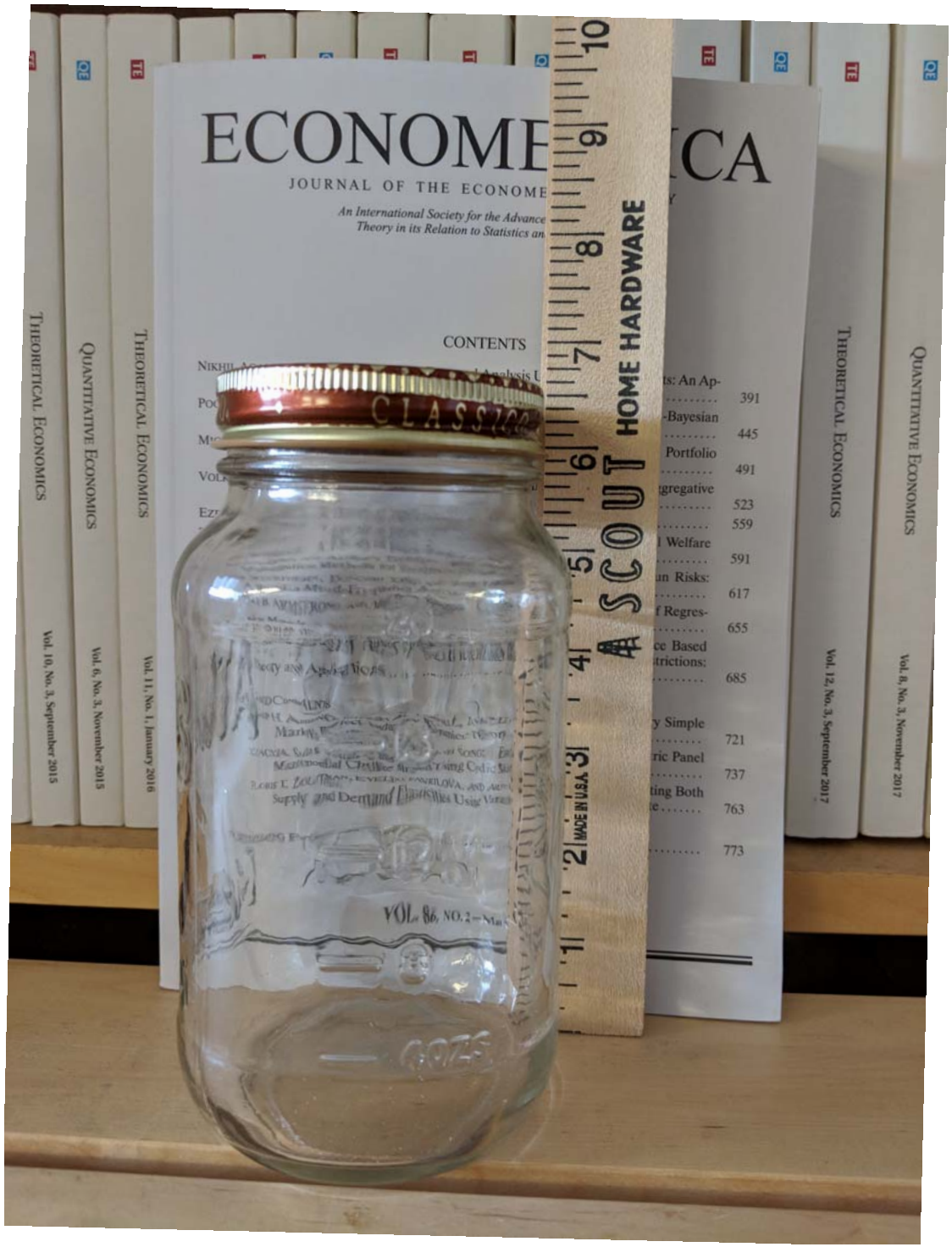
Variants: all-pay (lobbying), discriminatory, uniform, Vickrey (William Vickrey, Nobel Laureate 1996), and more.

Private-value / common-value

Bidders can be certain or uncertain about each other's valuation:

- In private-value auctions, valuations differ among bidders, and each bidder is certain of her own valuation and can be certain or uncertain of every other bidder's valuation.

- In common-value auctions, all bidders have the same valuation, but bidders do not know this value precisely and their estimates of it vary.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Types of games

We study four groups of game theoretic models:

I strategic games

II extensive games (with perfect and imperfect information)

III repeated games

IV coalitional games

Strategic games

A strategic game consists of

- a set of players (decision makers)
- for each player, a set of possible actions
- for each player, preferences over the set of action profiles (outcomes).

In strategic games, players move simultaneously. A wide range of situations may be modeled as strategic games.

A two-player (finite) strategic game can be described conveniently in a so-called bi-matrix.

For example, a generic 2×2 (two players and two possible actions for each player) game

	L	R
T	A_1, A_2	B_1, B_2
B	C_1, C_2	D_1, D_2

where the two rows (resp. columns) correspond to the possible actions of player 1 (resp. 2).

Applying the definition of a strategic game to the 2×2 game above yields:

- Players: $\{1, 2\}$
- Action sets: $A_1 = \{T, B\}$ and $A_2 = \{L, R\}$
- Action profiles (outcomes):

$$A = A_1 \times A_2 = \{(T, L), (T, R), (B, L), (B, R)\}$$

- Preferences: $\succsim_1$and $\succsim_2$are given by the bi-matrix.

Rock-Paper-Scissors

(over a dollar)

	R	P	S
R	$0, 0$	$-1, 1$	$1, -1$
P	$1, -1$	$0, 0$	$-1, 1$
S	$-1, 1$	$1, -1$	$0, 0$

Each player's set of actions is $\{Rock, Papar, Scissors\}$ and the set of action profiles is

$$\{RR, RP, RS, PR, PP, PS, SR.SP, SS\}.$$

In rock-paper-scissors

$$PR \sim_1 SP \sim_1 RS \succ_1 PP \sim_1 RR \sim_1 SS \succ_1 PS \sim_1 SR \sim_1 PS$$

and

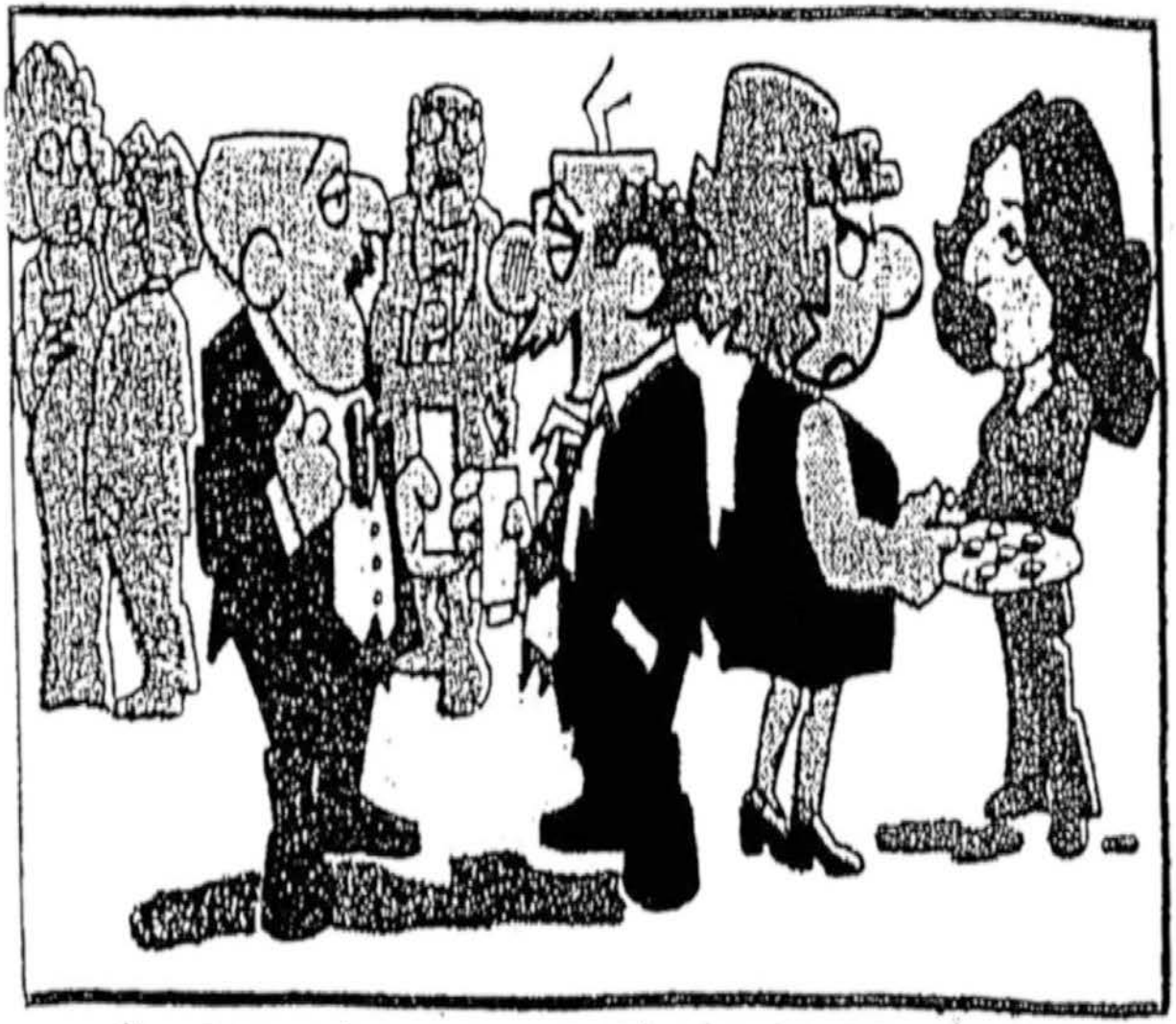
$$PR \sim_2 SP \sim_2 RS \prec_2 PP \sim_2 RR \sim_2 SS \prec_2 PS \sim_2 SR \sim_2 PS$$

This is a zero-sum or a strictly competitive game.

Nash equilibrium

Nash equilibrium (NE) is a steady state of the play of a strategic game – no player has a profitable deviation given the actions of the other players.

Put differently, a NE is a set of actions such that all players are doing their best given the actions of the other players.



"LORETTA'S DRIVING BECAUSE I'M DRINKING,
AND I'M DRINKING BECAUSE SHE'S DRIVING."

Food for thought

LUPI

Many players simultaneously chose an integer between 1 and 99,999. Whoever chooses the lowest unique positive integer (LUPI) wins.

Question What does an equilibrium model of behavior predict in this game?

The field version of LUPI, called Limbo, was introduced by the government-owned Swedish gambling monopoly Svenska Spel. Despite its complexity, there is a surprising degree of convergence toward equilibrium.

Morra

A two-player game in which each player simultaneously hold either one or two fingers and each guesses the total number of fingers held up.

If exactly one player guesses correctly, then the other player pays her the amount of her guess.

Question Model the situation as a strategic game and describe the equilibrium model of behavior predict in this game.

The game was played in ancient Rome, where it was known as "micatio."

Maximal game
(sealed-bid second-price auction)

Two bidders, each of whom privately observes a signal X_i that is independent and identically distributed (i.i.d.) from a uniform distribution on $[0, 10]$.

Let $X^{\max} = \max\{X_1, X_2\}$ and assume the ex-post common value to the bidders is $X^{\max}$.

Bidders bid in a sealed-bid second-price auction where the highest bidder wins, earns the common value $X^{\max}$ and pays the second highest bid.