Више од игре

Теорија игара у економији, еволуцији и екологији

Н. Швракић

Misnomer kao i Teorija Relativnosti

Žorž de la Tour (1635)

2012 Katar je kupio ovu sliku za 250 miliona dolara
Dobra ili loša investicija?

- From simplest to most complex:
  - Subatomic particles
  - Atom
  - Molecule
  - Macromolecule
  - Organelles
  - Cell
  - Tissue
  - Organs
  - Organ system
  - Organism
  - Population
  - Community
  - Ecosystem
  - Biomes
  - Biosphere

Textbook p. 21

Levels of Organization

Subatomic particles →

Atoms → Molecules

Organic molecules →

Cells → Tissue →

Organs → Organ systems

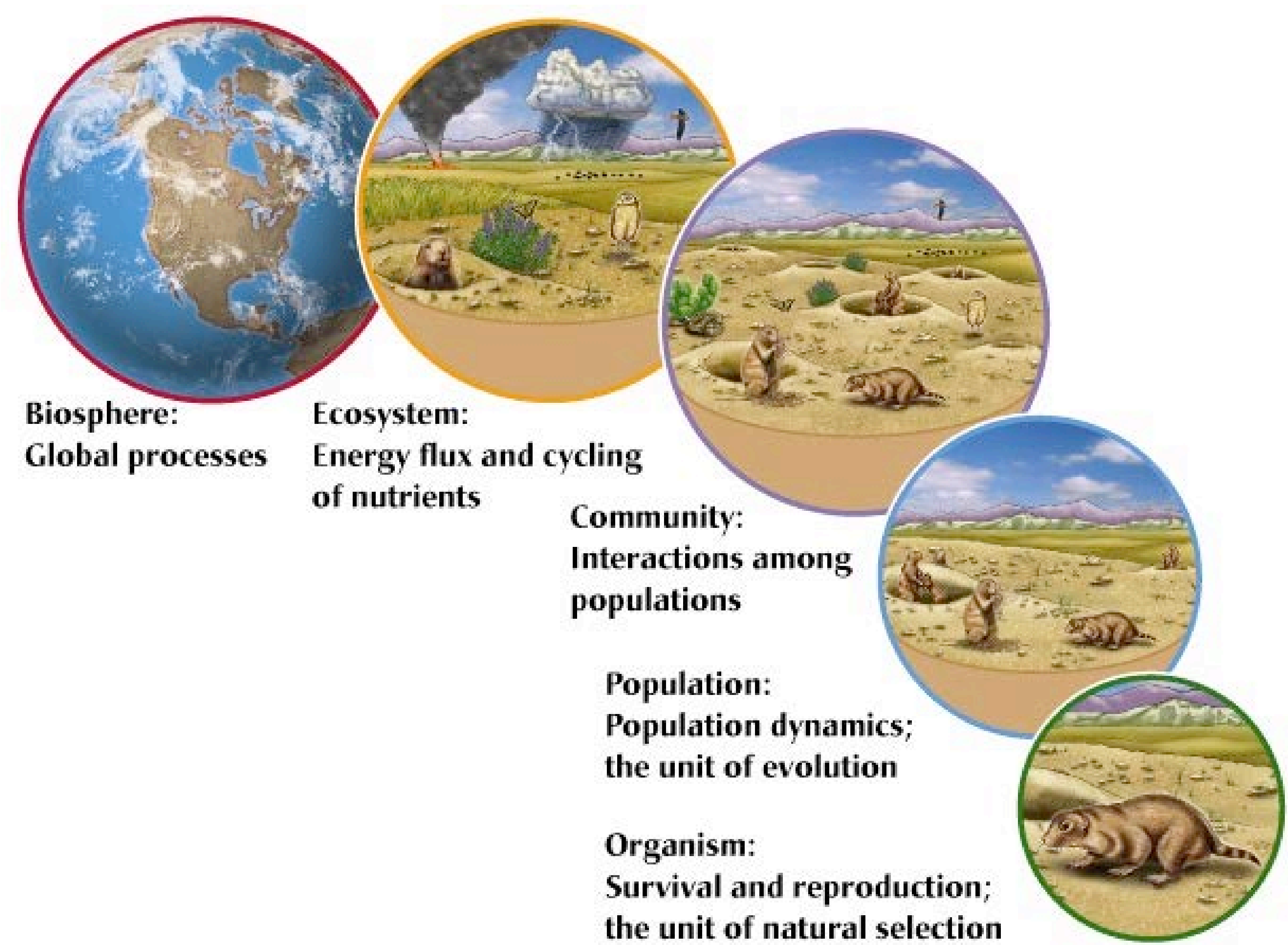
→ Organism →

Population →

Community →

Ecosystem → Biosphere

Teorija materije redukcionistička. Teorija igara konstruktivistička.
Social dilemma
Anderson – More is different



4 August 1972, Volume 177, Number 4047

SCIENCE

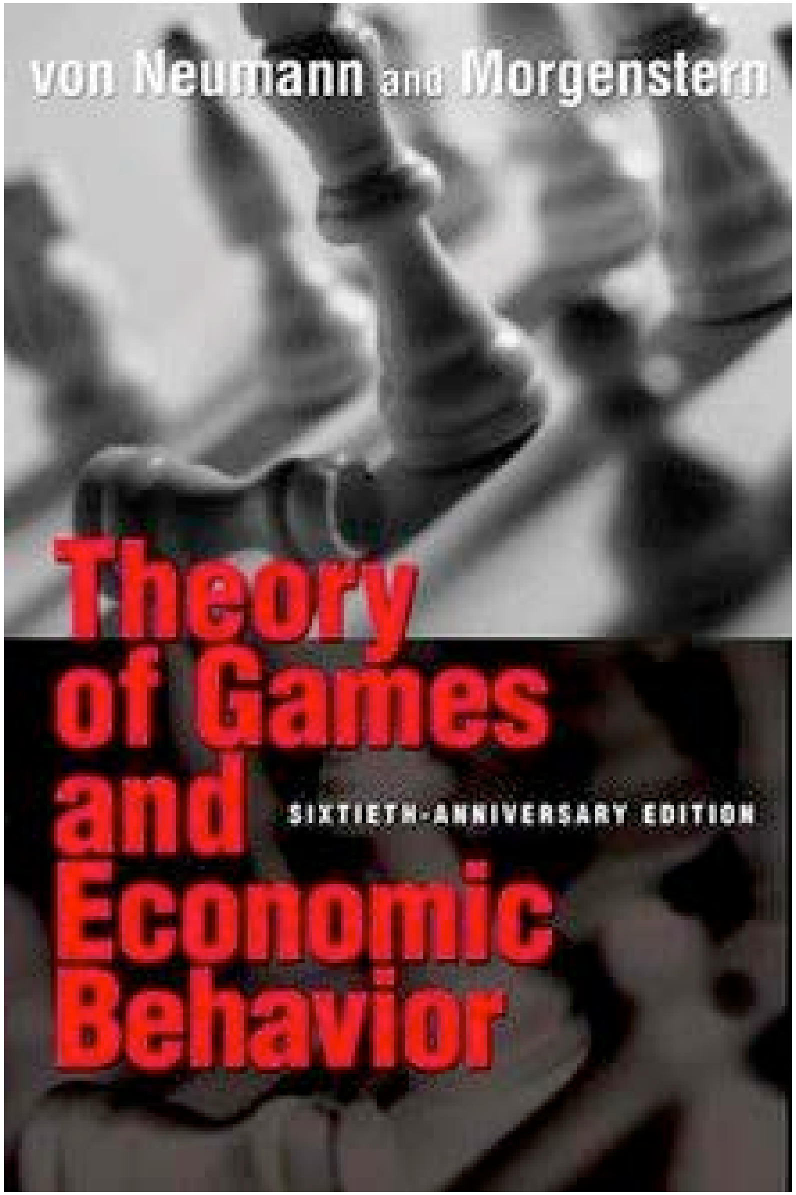
More Is Different

Broken symmetry and the nature of the hierarchical structure of science.

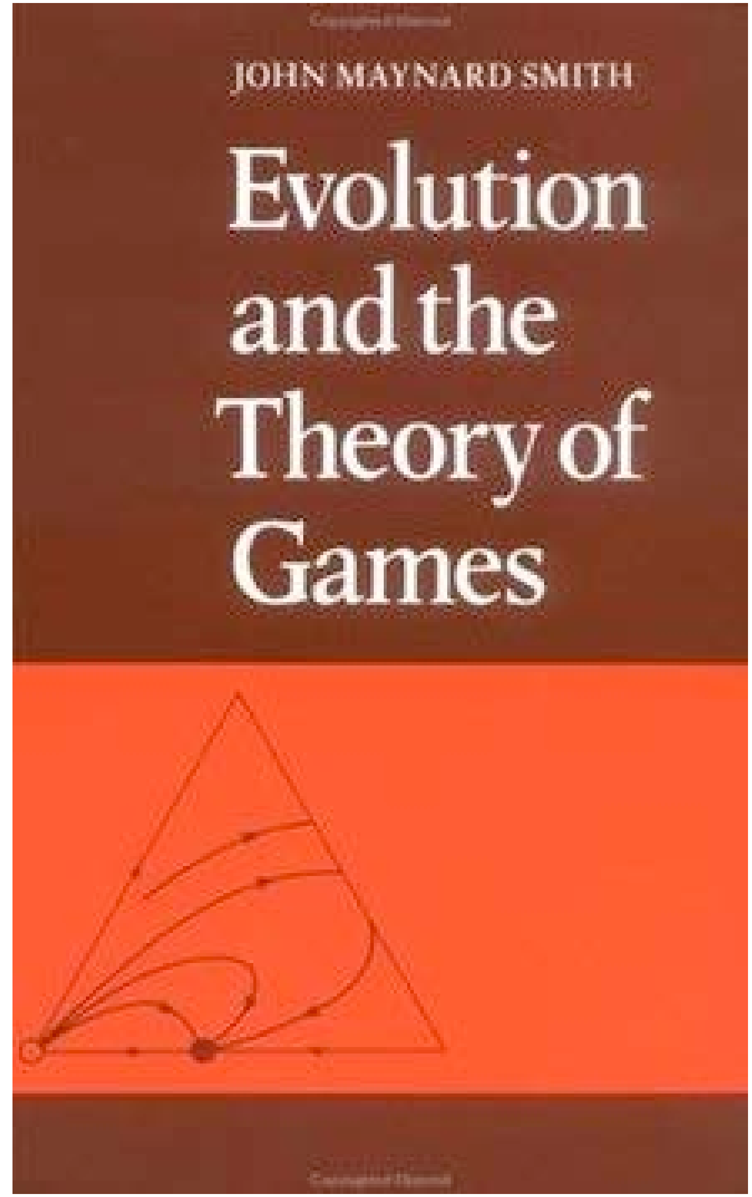
P. W. Anderson

The reductionist hypothesis may still be a topic for controversy among philosophers, but among the great majority of active scientists I think it is accepted without question. The workings of our planation of phenomena in terms of known fundamental laws. As always, distinctions of this kind are not unambiguous, but they are clear in most cases. Solid state physics, plasma physics, and perhaps also biology are extensive. High energy less relevance they seem to have to the very real problems of the rest of science, much less to those of society.

The constructionist hypothesis breaks down when confronted with the twin difficulties of scale and complexity. The behavior of large and complex aggregates of elementary particles, it turns out, is not to be understood in terms of a simple extrapolation of the properties of a few particles. Instead, at each level of complexity entirely new properties appear, and the understanding of the new behaviors requires research which I think is as fundamental in its nature as any other. That is, it seems to me that one may array the sciences roughly linearly in a hierarchy, according to the idea: The elementary entities of science X obey the laws of science Y.


von Neumann and Morgenstern
Theory of Games and Economic Behavior
SIXTIETH-ANNIVERSARY EDITION

1944

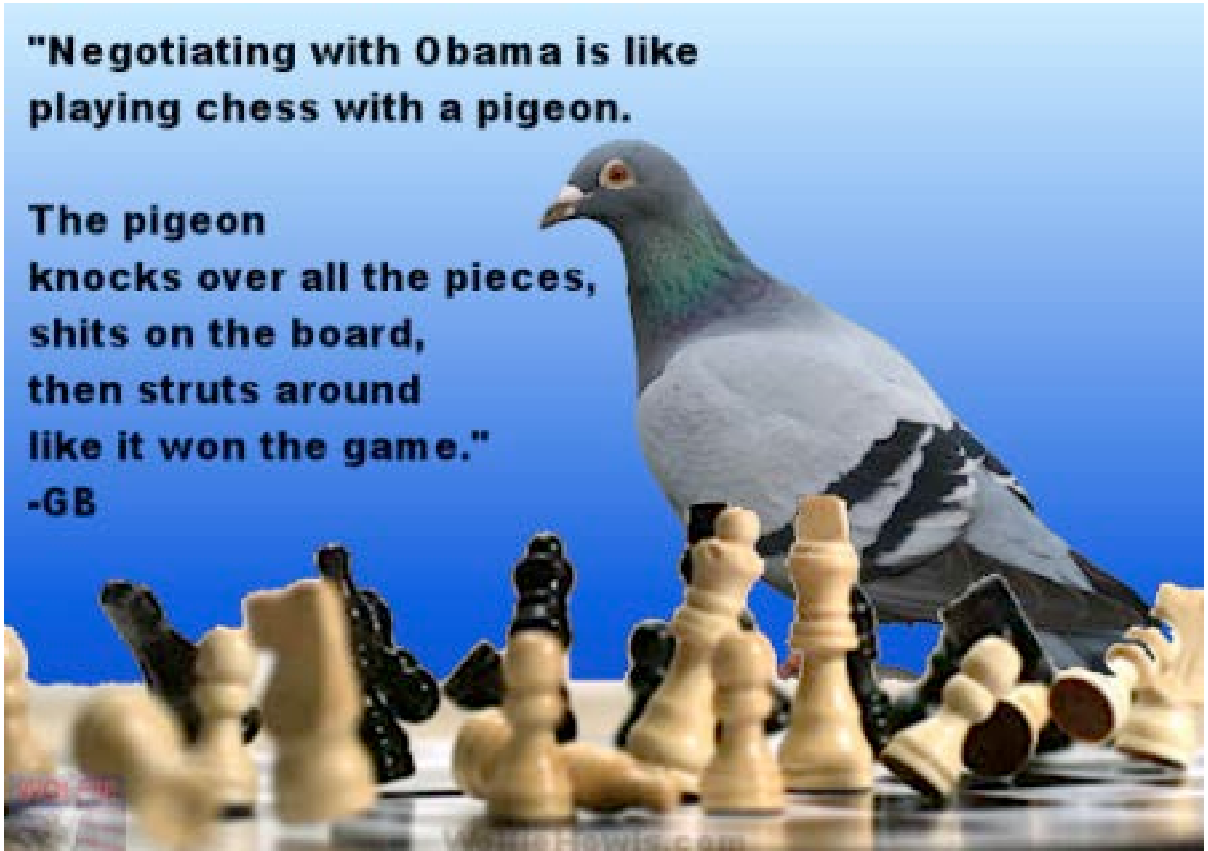

JOHN MAYNARD SMITH
Evolution and the Theory of Games

1982

John Nash (1928-2015)		Nash equilibrium – Nobelova nagrada 1994

Teorija igara počinje opisom igre*. U igri mogu da učestvuju dva ili više igrača. Postoje igre sa beskonačno mnogo igrača, prostorne igre, itd. (videti dole). Najvažnije u opisu igre je „dobit" (payoff) koju svaki igrač stekne na završetku igre, i ta dobit zavisi od strategije koju je primenio igrač i koju su primenili drugi igrači. Ovo poslednje je ključni i centralni motiv TI: dobit zavisi ne samo od toga šta igrač radi, već i od strategije dugih učesnika u igri. (U tom smislu je TI neredukcionističk teorija). Matematički, igra se izražava preko **matrice isplatljivosti** (payoff matrix) za definisane strategije.

Pravila igre



Rat polova (War of the sexes)

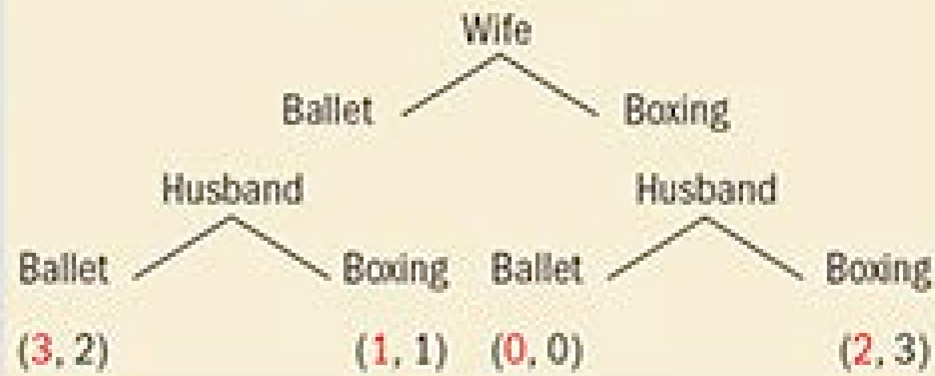
The game

Whether the players, in this case, spouses, make entertainment decisions simultaneously or sequentially, they maximize payoff when both attend the same event.

Simultaneous moves

		Wife: Ballet	Wife: Boxing
Husband	Ballet	(3, 2)	(0, 0)
	Boxing	(1, 1)	(2, 3)

Sequential moves



Note: The payoff for the wife is in red, for the husband in black. The payoff amounts for each are 2 points if they attend the same event, 1 point if they attend their preferred event (ballet for the wife, boxing for the husband), and zero if they attend the event they do not like. In the simultaneous game, each makes the decision without knowledge of the other's choice. In the sequential game, the person picking second knows what the other person chose.

Rat polova

Važna karakteristika ove igre je u tome što je ovo **igra koordinacije**, naime pri odlučivanju za strategiju (balet ili boks), svaki igrač mora da razmišlja o tome šta će onaj drugi da uradi. Ova igra ilustruje i nekoliko drugih važnh aspekata teorije igara.

Prvo**, gde je ovde rat?** Zamislimo da je muž veoma fini i odluči se da udovolji ženi i izabere balet, a žena je jako fina i želi da udovolji mužu, te izabere boks meč. U tom slučaju svako dobije 0 poena, jer su otišli na različita mesta koja još i ne preferiraju! U obrnutoj situaciji, kad su oboje sebični, žena će da ode na balet a muž na boks, što im opet donosi po 0 poena jer nisu zajedno (a to je osnovna ideja ove igre). Zaključak: totalno fini ili totalno sebični par je uvek na gubitku - samo ako je jedan fini a drugi sebičan oboje imaju neku korist. Jasno je **da ne postoji verzija u kojoj je dobit (3,3)**, pa neko mora da se „žrtvuje" ili da „popušta". I eto nama rata!

Drugi važan aspekt ove igre je u tome da postoje odluke u kojoj oba igrača dobijaju - kombinacije kad provedu veče zajedno, tj., **dobit jednog nije automatski i gubitak za drugog**. Ovakve igre se još zovu **i non zero-sum games**. Igre gde je dobitak jednog gubitak za drugog (sportski mečevi eliminacije, na primer) često dovode do oštre borbe i neprijateljstva, se zovu **zero-sum games**, i treba ih na svaki način izbegavati.

Rat polova - analiza

Treća važna osobina ove igre je sledeća: zamislimo da muž ima slobdu da promeni svoju strategiju, a žena ne. U tom slučaju, ako je muževa dobit manja sa promenom strategije, on će se se vratiti na staru - recimo ako je muž prvobitno odlučio da ide na balet (kao i žena), on će, promenivši tu odluku, otići sam na boks meč i neće dobiti ništa. Zato će se ipak na kraju odlučiti za balet. (Slično važi i za ženu u obnutoj situaciji). Postoji, dakle, izbor odluka koji je takav da ako jedan igrač promeni svoju strategiju, a drugi igrači svoje ne promene, taj igrač koji je promenio strategiju ne dobija više. U slučaju muža i žene postoje dva takva izbora – boks/boks ili balet/balet. *Ovakav izbor strategija gde promena strategije od strane jednog igrača, pri nepromenjenim odlukama drugih igrača, ne donosi igraču sa promenjenom strategijom boljitak, i ako to važi za svakog igrača pojedinačno, se zove* ***Nešova ravnoteža*** *(Nash equilibrium)***. Rat izmedju muskaraca i žena je igra koja ima dve Nešove ravnoteze.**

Zamislimo, dalje, neku igru sa mnogo igrača i mnogo strategija, i zamislimo da je svaki igrač odabrao svoju strategiju. Nešova ravnoteža je postignuta ako, pri fiksiranim odlukama drugih igrača, promena strategije jednog od njih ne donosi ovome boljitak. Neš je pokazao da u opštem slučaju ovakav sistem ima ravnotežnu (stabilnu) konfigraciju strategija gde se nikome ne isplati da svoju menja. Za ovaj dokaz je Neš dobio Nobelovu nagradu.

Primetimo da na Nešovoj ravnoteži ne mora svaki igrač da bude maksimalno zadovoljan svojom dobiti upotrebivši strategiju koju je odabrao, on jedino neće svoj stanje poboljšati ako strategiju promeni. Drugo, Nešova ravnoteža ne govori o tome koju strategiju treba primeniti, niti daje neke savete u tom smislu. Ona samo kaže da **postoji skup strategija koje su u ravnoteži.** Da li će igrači da pronadju takav skup, i da li će ga pronaći brzo ili ne, je pitanje od fundamentalnog značaja, ali o tome Nešova teorija ne govori.

Igre života i smrti

The Logic of Animal Conflict

J. MAYNARD SMITH
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G. R. PRICE
Galton Laboratory, University College London, 4 Stephenson Way, London NW1 2HE

Conflicts between animals of the same species usually are of "limited war" type, not causing serious injury. This is often explained as due to group or species selection for behaviour benefiting the species rather than individuals. Game theory and computer simulation analyses show, however, that a "limited war" strategy benefits individual animals as well as the species.

and ask what strategy will be favoured under individual selection. We first consider conflict in species possessing offensive weapons capable of inflicting serious injury on other members of the species. Then we consider conflict in species where serious injury is impossible, so that victory goes to the contestant who fights longest. For each model, we seek a strategy that will be stable under natural selection; that is, we seek an "evolutionarily stable strategy" or ESS. The concept of an ESS is fundamental to our argument; it has been derived in part from the theory of games, and in part from the work of MacArthur[13] and of Hamilton[14] on the evolution of the sex ratio. Roughly, an ESS is a strategy such that, if most of the members of a population adopt it, there is no "mutant" strategy that

What is an ESS?

- Strategy = the behavioral response of an individual
- ESS = a strategy which if adopted by all members of a population cannot be invaded by any alternative strategy
- The ESS is found using game theory. Game theory is needed when the fitness consequences of a behavior depend on what others are doing, i.e. is frequency dependent

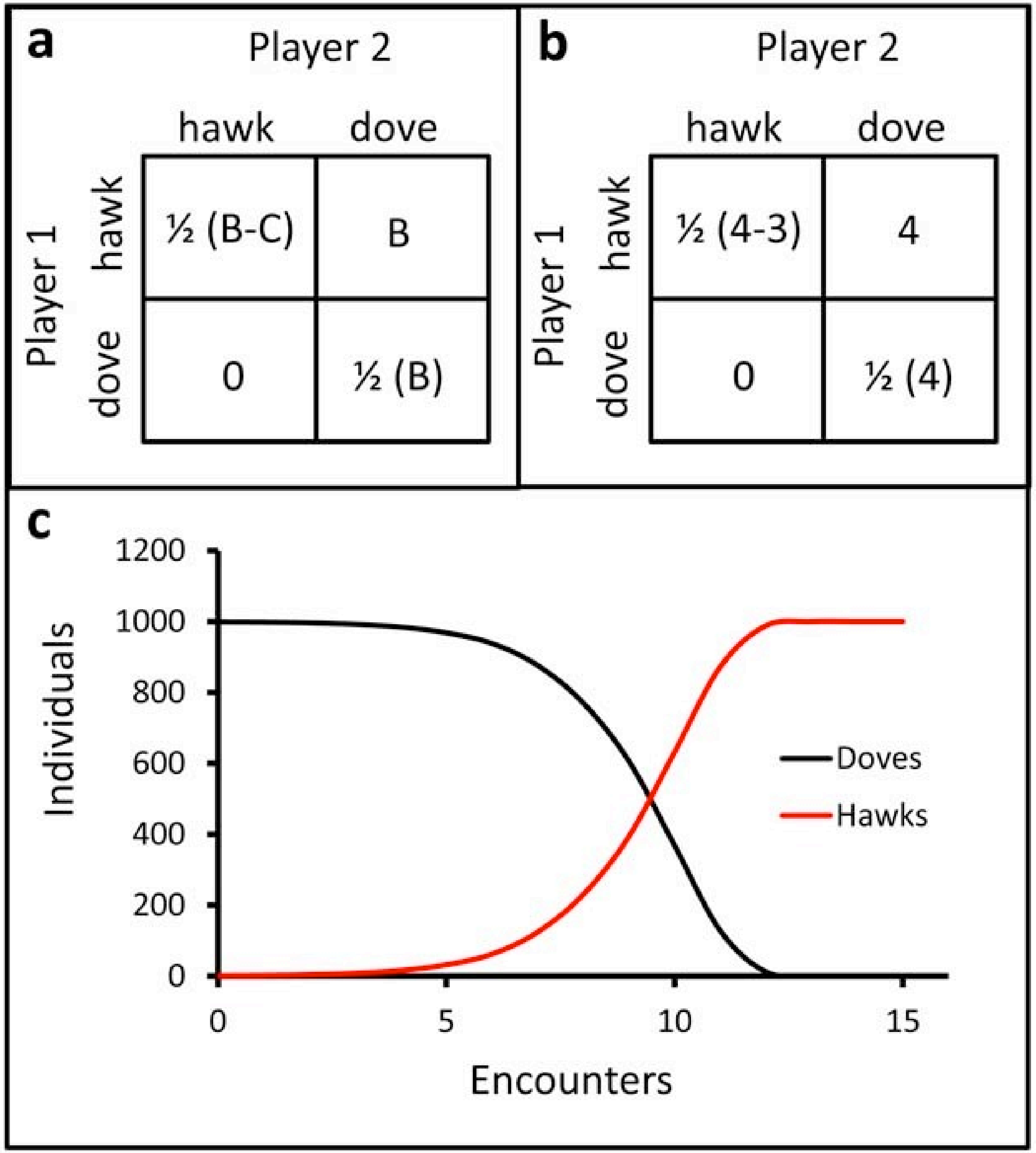
If two animals fight for a limited resource, and are given only the two choices to (a) fight (be a "Hawk"), or (b) walk away (be a "Dove"), then two Doves will peacefully share the full resource between them, having established that neither is going to attack. If two Hawks meet, they will also share the resource in some (perhaps random) way, but both will have incurred some 'cost' in fighting (the cost may be random and very high). If, on the other hand, a Hawk and a Dove meet, the Hawk will get everything at zero cost and the Dove gets nothing.

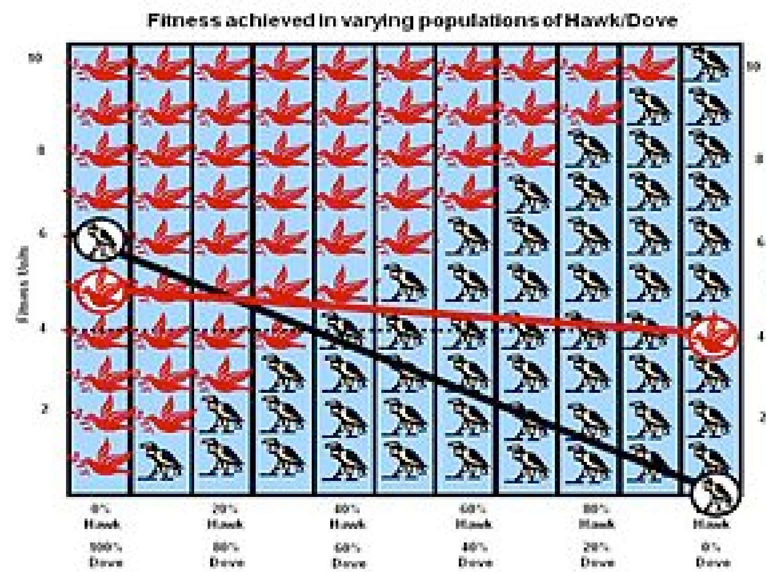
Evolutionary game theory

- Example (Hawk-Dove Game)
  - H: aggressive; D: mild
  - Population strategy $\boldsymbol{x} = (x, 1 - x)$
  - Mixed strategy (H,D) of an individual $\sigma = (p, 1 - p)$
  - Payoff matrix (v<c):

	Hawk	Dove
Hawk	(V-C)/2, (V-C)/2	V, 0
Dove	0, V	V/2, V/2

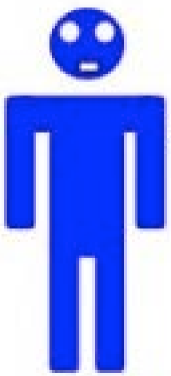
  - Suppose the existence of an ESS $\boldsymbol{x}^* = (p^*, 1 - p^*)$


a
Player 2
hawk
dove
Player 1
hawk
dove
½ (B-C)
B
0
½ (B)
b
Player 2
hawk
dove
Player 1
hawk
dove
½ (4-3)
4
0
½ (4)
c
Individuals
1200
1000
800
600
400
200
0
0
5
10
15
Encounters
Doves
Hawks


Fitness achieved in varying populations of Hawk/Dove
Fitness Units
0% Hawk 100% Dove
20% Hawk 80% Dove
40% Hawk 60% Dove
60% Hawk 40% Dove
80% Hawk 20% Dove
100% Hawk 0% Dove

A GAME OF CHICKEN

	IF DRIVER #2... ...SWERVES, THEN...	IF DRIVER #2... ...DRIVES STRAIGHT, THEN...
IF DRIVER #1... ...SWERVES, THEN...	...it's a tie.	...driver #2 wins and driver #1 loses.
IF DRIVER #1... ...DRIVES STRAIGHT, THEN...	...driver #1 wins and driver #2 loses.	...both drivers crash.



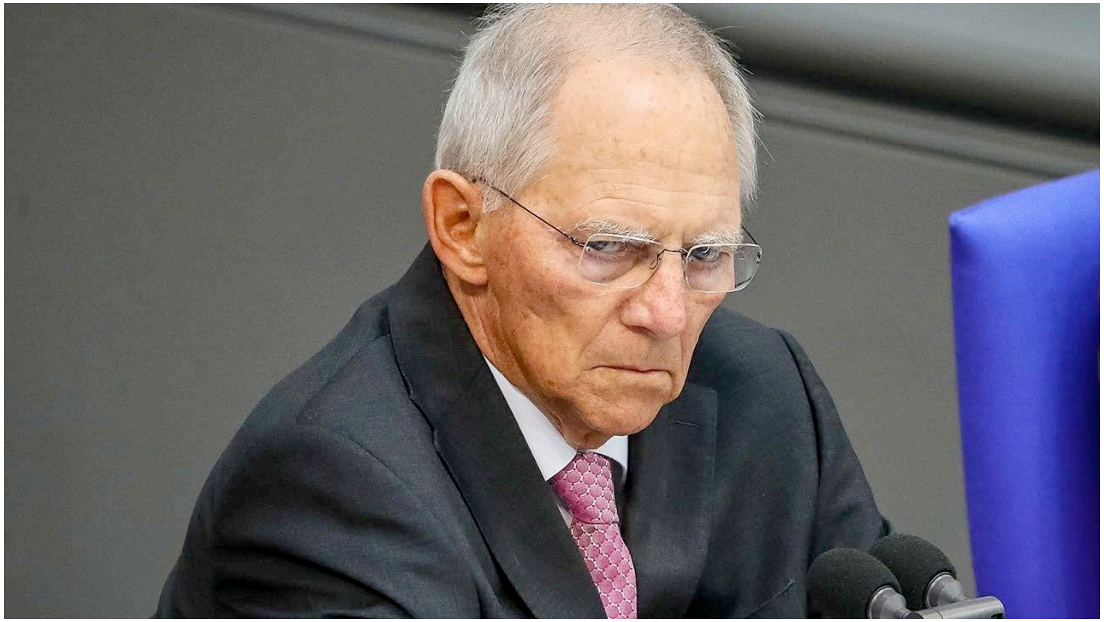
	SWERVE	STRAIGHT
SWERVE	0 , 0	-1 , 1
STRAIGHT	1 , -1	-5 , -5

The game the EU and Greece have settled on is called “chicken” in game theory. In this game both sides are big losers if no-one yields, but the act of yielding extracts a heavy price in terms of reputation, which will hurt you especially if you have to repeat the game in the future.

Traditionally, it’s set up as two cars heading straight for each other, with the one who swerves being the loser. If no-one swerves both die. You get the point. The Cuban missile crisis was sometimes used as a real-world example, but a better example is the hawk-dove game played by animals and people, first described by the evolutionary theorists John Maynard Smith and George Price. Here is how that one works:

In politics, you get into a game of chicken when the political or reputational cost of giving in has become very high. That’s were Brussels, Berlin, and the Greek government are in respect of their electorate. Both have drummed up voter rhetoric that makes it very, very costly to back down. Famously, the key to solving the Cuban missile crisis was to give Krushchev a face-saving ‘way out’, telling the Russian public that the US backed down from an invasion. Krushchev even proposed to give Kennedy a way out by offering to pretend that the Russian ships never carried any nukes in the first place.

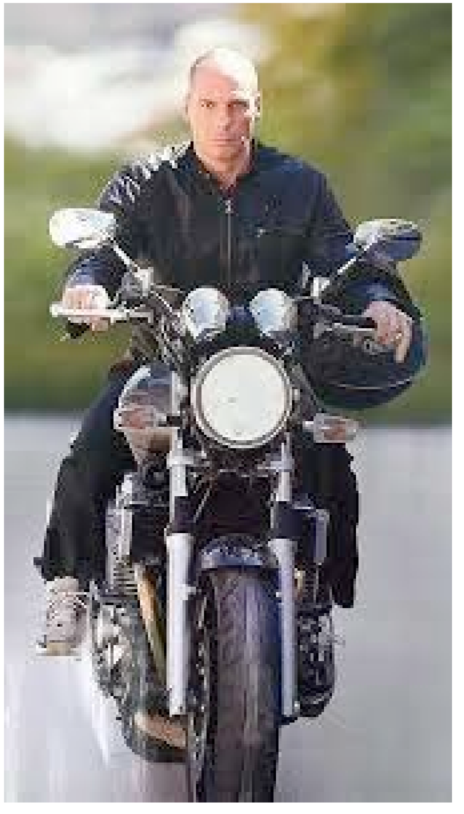
Varoufakis had to strike a difficult balancing act: (1) playing the game of chicken as best he can, appearing mad, unreliable as a negotiating partner, cut from a different mold as the Eurocrats, and dragging his feet on concessions. But (2) he also has to play to the rank and file in Greece, and to his fellow ministers, who want to be assured that he isn’t actually mad. But that means the game isn’t a two-player game of chicken. When you are in the car together with 10 million others, 15 or 20 are in charge, and everyone is discussing loudly what you should be doing, it gets difficult to pretend to be a Hawk. It’s not “chicken”, it’s radio-broadcast-chicken. That’s where his job becomes that much harder. Politics trumps game theory here.



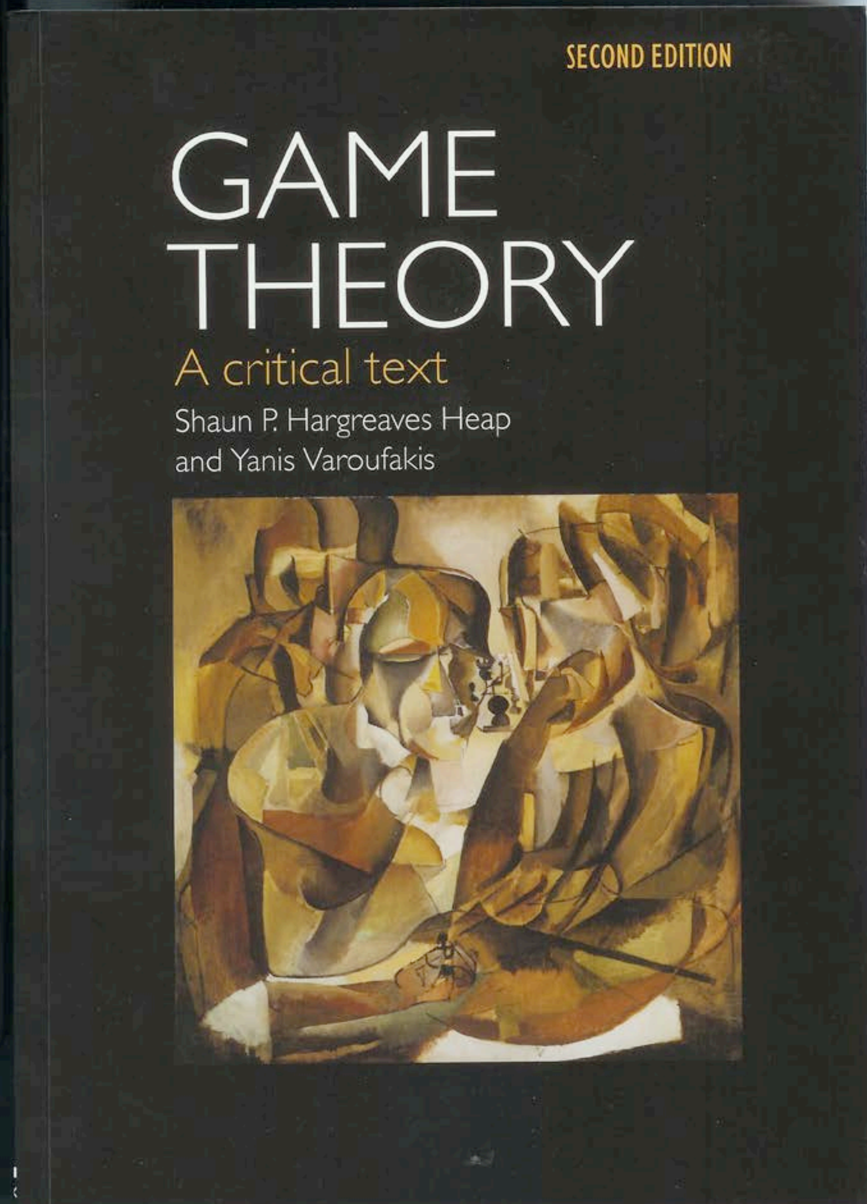
Wolfgang Schäuble

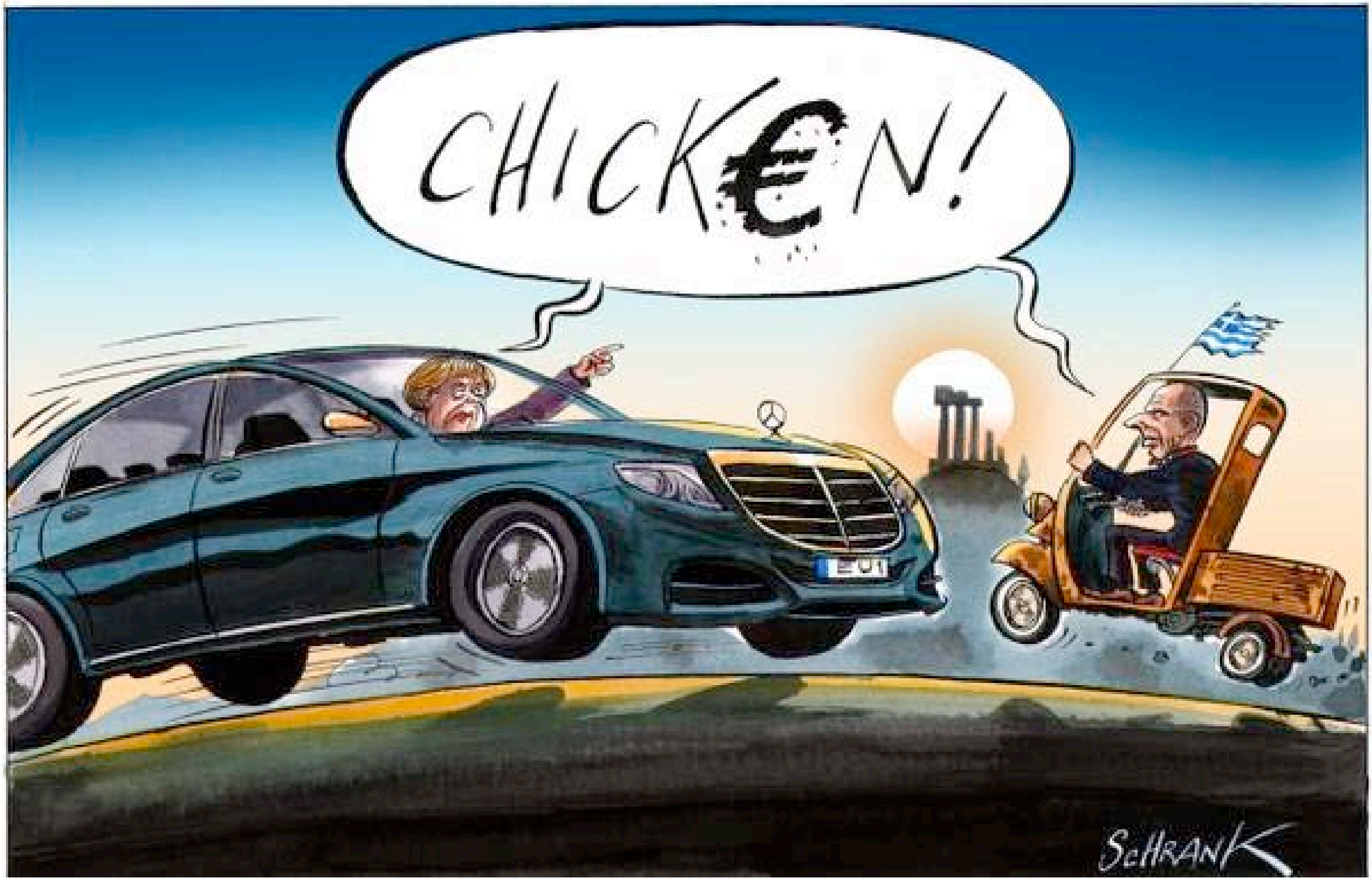
Yanis Varoufakis

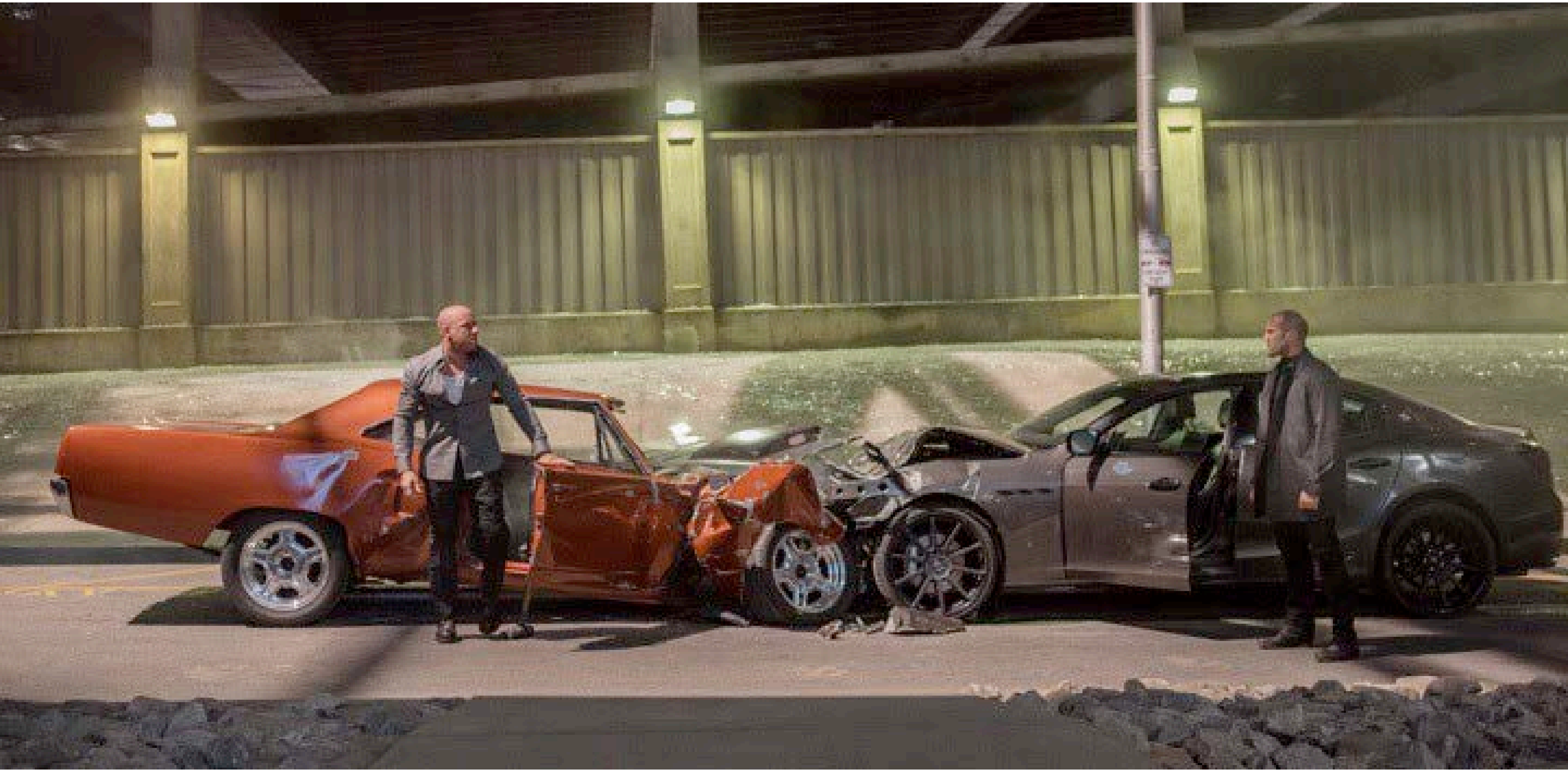
“A sav ćar mu je bio ako štete nije imao” -?



We don’t need an Ancient Greek hero, we need someone who can lead this country

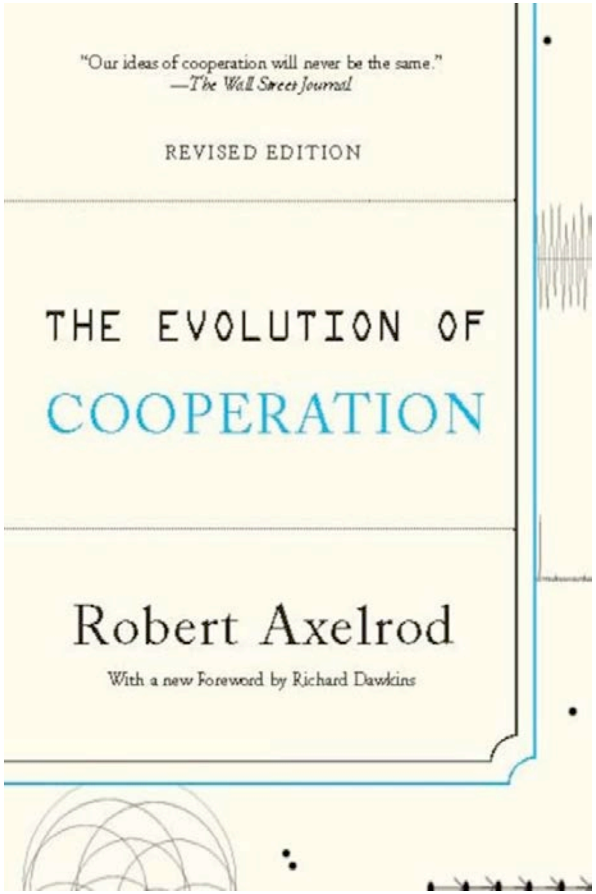

SECOND EDITION
GAME THEORY
A critical text
Shaun P. Hargreaves Heap
and Yanis Varoufakis


CHICKEN!
SCHRANK



Evolucija saradnje (kooperacije)

Dawkins-Axelrod-TFT

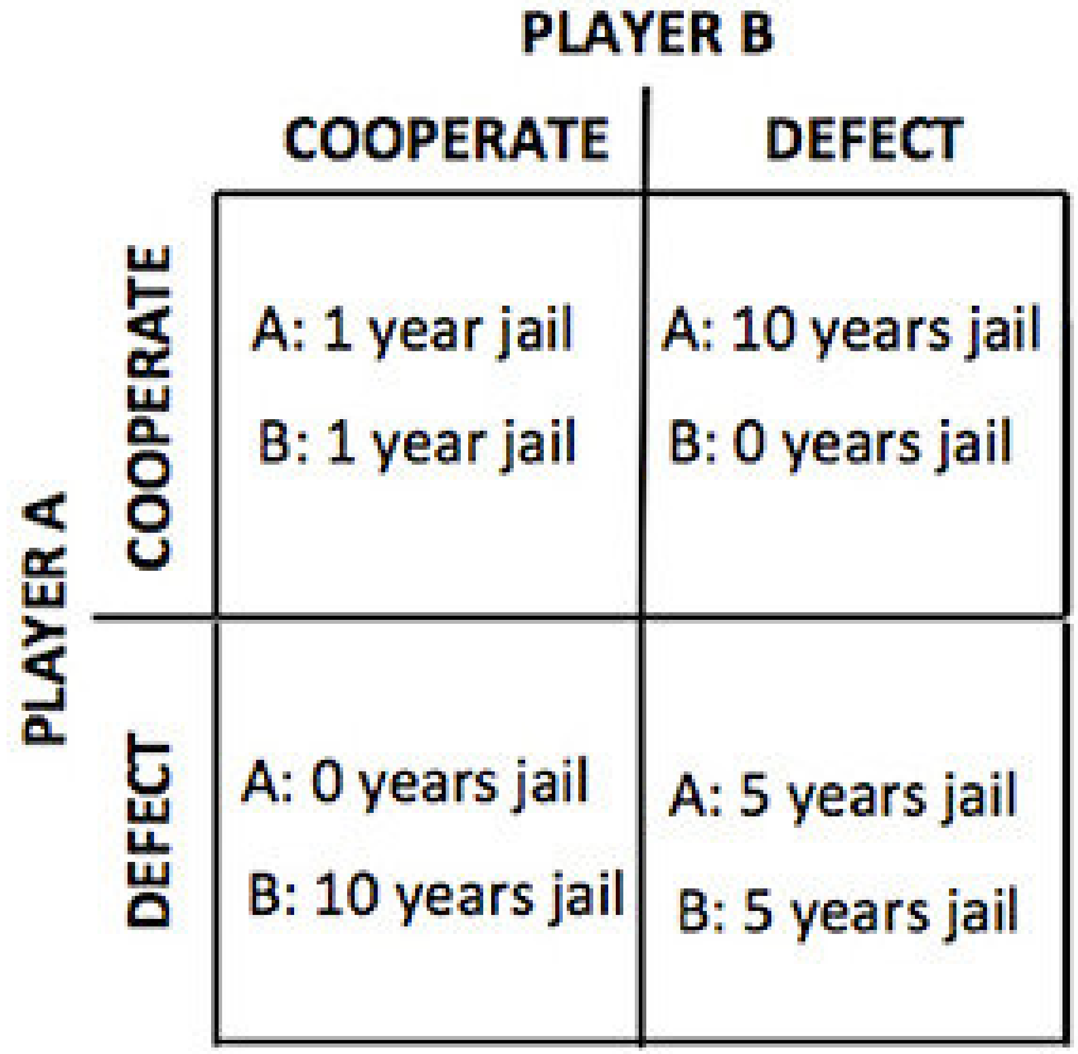


Igre **saradnje**

The prisoner's dilemma

Prisoner A \ Prisoner B	Confess	Keep quiet
Confess	Both go to jail for ten years	Prisoner B gets life imprisonment, A goes free
Keep quiet	Prisoner A gets life imprisonment, B goes free	Both go to jail for one year

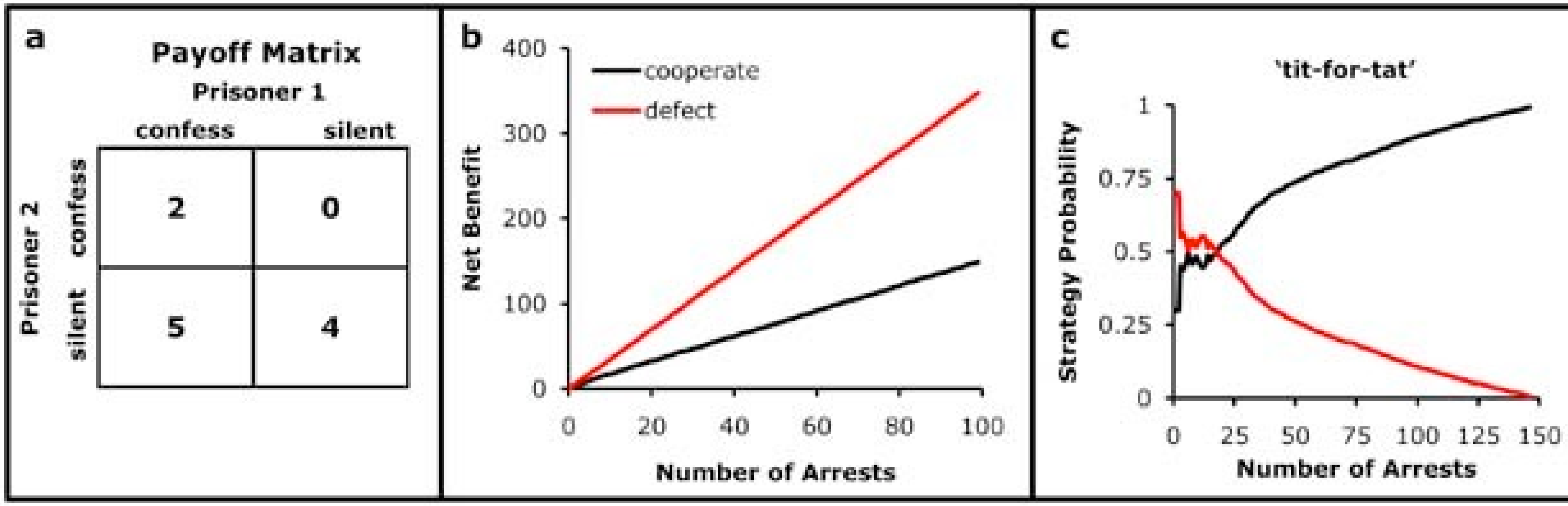
Economist.com



		PLAYER B	
		COOPERATE	DEFECT
PLAYER A	COOPERATE	A: 1 year jail B: 1 year jail	A: 10 years jail B: 0 years jail
	DEFECT	A: 0 years jail B: 10 years jail	A: 5 years jail B: 5 years jail

Dobitna strategije je D

Iterisana Zatvorenikova Dilema



a
Payoff Matrix
Prisoner 1
confess
silent
Prisoner 2
confess
silent
2
0
5
4
b
cooperate
defect
Net Benefit
400
300
200
100
0
0
20
40
60
80
100
Number of Arrests
c
'tit-for-tat'
Strategy Probability
1
0.75
0.5
0.25
0
0
25
50
75
100
125
150
Number of Arrests

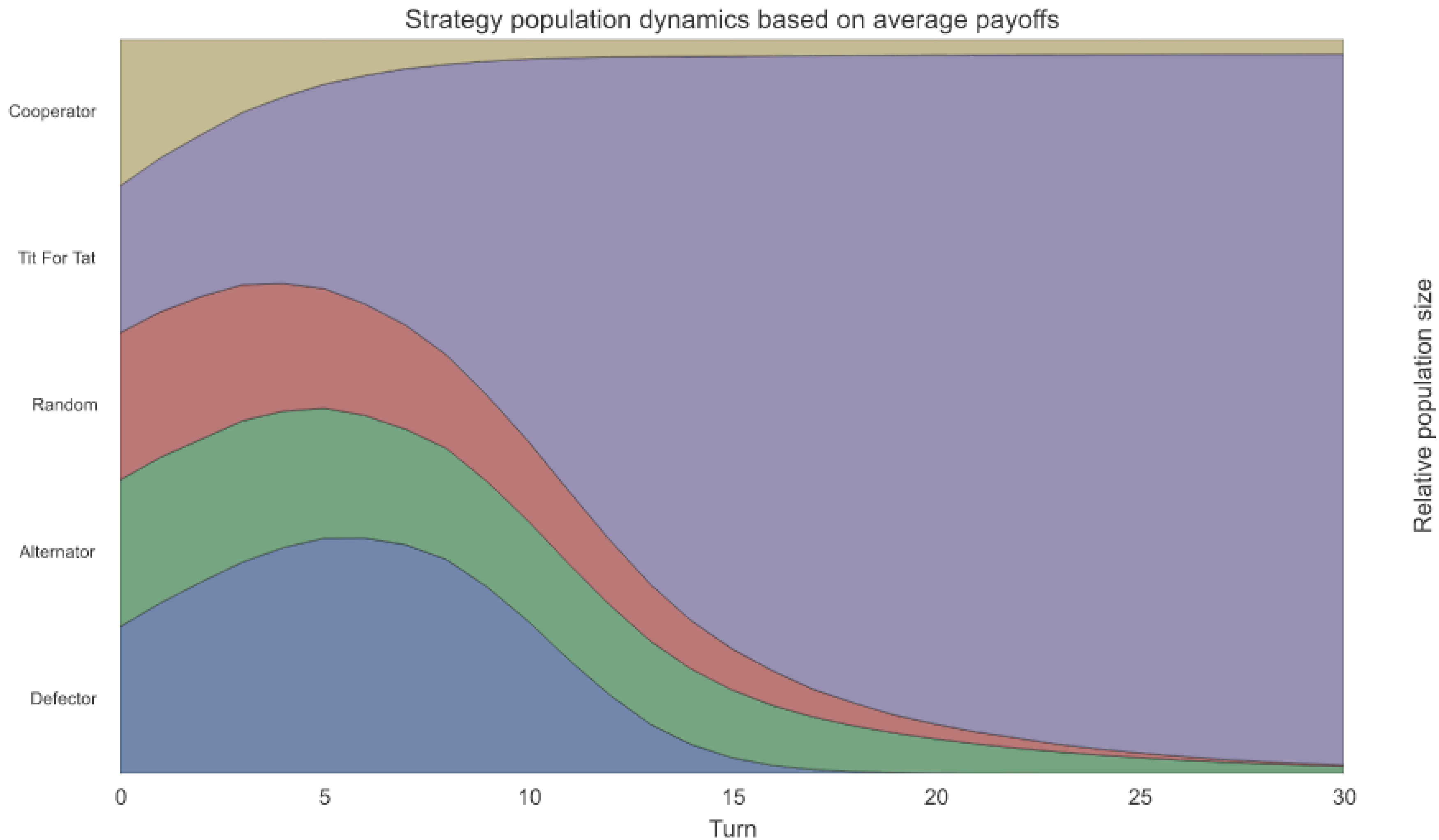
Axelrod's conclusions

- **Be Nice** (never be first to defect)
- **Be Forgiving** (be willing to cooperate if cooperation is offered)
- **Be Retaliatory** (be willing to defect if others defect against you)
- **Be Clear** (be transparent about what your strategy is – make it easy to infer)

TIT FOR TAT has all these attributes.

Primetimo da ovde ključnu ulogu igra **poverenje**. Ako, na primer, ja ne mogu sam da napravim sebi kuću, ali uz pomoć druge osobe mogu, onda nam je obojici najbolje ako ti pomogneš meni i napravimo za mene kuću, i ja pomognem tebi i napravimo za tebe kuću. Tada ćemo obojica svaki imati po kuću (dobit) koju smo stekli saradnjom, i kakvu ne bi mogli da imamo da smo delovali svaki za sebe. **Hobs** je, imajući ovo u vidu, i ne poznajući formalnu teoriju igara, čak predlozio da ljudsko društvo može uspešno da postoji samo ako se ljudi tiranijom primoraju da se drže dogovora - svako nepridržavanje bi bilo drastično kažnjavano, a sve u interesu opstanka i napredovanja društva.

Evolucija, ili razvijanje saradnje (kooperacije) se oslanja na dva važna faktora: (i) da igrači prepoznaju jedan drugog (poverenje), i (ii) da je, na duge staze, kumulativna zajednička i pojedinačna dobit, pri kooperaciji, veća od svake pojedinačne zasebno.



Adding **noise** to the game — a random change in strategy that acts as a stand-in for genetic mutation — ends the reign of tit for tat. Under these circumstances, a variant known as **generous tit for tat (Hristos)**, which involves occasionally forgiving another's betrayal,

Overcoming the Prisoners' Dilemma

Repeated Interaction and Tacit Collusion

Players who don't take their interdependence into account arrive at a *Nash*, or *non-cooperative*, *equilibrium*. But if a game is played repeatedly, players may engage in *strategic behavior*, sacrificing short-run profit to influence future behavior.

In repeated prisoners' dilemma games, *tit for tat* is often a good strategy, leading to successful *tacit collusion*.

When firms limit production and raise prices in a way that raises each others' profits, even though they have not made any formal agreement, they are engaged in **tacit collusion.**

Applied to the real world, economists use the Nash equilibrium to predict how companies will respond to their competitors' prices. Two large companies setting pricing strategies to compete against each other will probably squeeze customers harder than they could if they each faced thousands of competitors.

The Nash equilibrium helps economists understand how decisions that are good for the individual can be terrible for the group. This **tragedy of the commons** explains why we overfish the seas, and why we emit too much carbon into the atmosphere. Everyone would be better off if only we could agree to show some restraint.

Snowdrift game

Vervet monkey

A BAT'S DILEMMA

Game theory can model the choice to share a meal with a hungry neighbor.

	Bat A shares	**Bat A** doesn't share
Bat B shares	 Both survive, if a little hungrier. Bat A fitness: 0.9 Bat B: 0.9	 Bat A stays full; Bat B dies. Bat A fitness: 1 Bat B: 0
Bat B doesn't share	 Bat B stays full; Bat A dies. Bat A fitness: 0 Bat B: 1	 Each survives alone; much hungrier. Bat A fitness: 0.4 Bat B: 0.4

The Nash equilibrium helps economists understand how decisions that are good for the individual can be terrible for the group. This **tragedy of the commons** explains why we overfish the seas, and why we emit too much carbon into the atmosphere. Everyone would be better off if only we could agree to show some restraint.

PNAS
Proceedings of the National Academy of Sciences of the United States of America

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Iterated Prisoner's Dilemma contains strategies that dominate any evolutionary opponent

William H. Press and Freeman J. Dyson

PNAS June 26, 2012 109 (26) 10409-10413; https://doi.org/10.1073/pnas.1206569109

Contributed by William H. Press, April 19, 2012 (sent for review March 14, 2012)

Nat Commun. 2016 Apr 12;7:11125. doi: 10.1038/ncomms11125.

Extortion can outperform generosity in the iterated prisoner's dilemma.

Wang Z[1,2], Zhou Y[1,2], Lien JW[3,4], Zheng J[4,5], Xu B[6].

PLoS One. 2016 Oct 4;11(10):e0163867. doi: 10.1371/journal.pone.0163867. eCollection 2016.

Asymmetric Power Boosts Extortion in an Economic Experiment.

Hilbe C[1,2], Hagel K[3], Milinski M[3].

⊖ Author information

1 Program for Evolutionary Dynamics, Department of Organismic and Evolutionary Biology and Department of Mathematics, Harvard University, Cambridge MA, United States of America.

2 IST Austria, Klosterneuburg, Austria.

3 Department of Evolutionary Ecology, Max-Planck-Institute for Evolutionary Biology, Plön, Germany.

Abstract

Direct reciprocity is a major mechanism for the evolution of cooperation. Several classical studies have suggested that humans should quickly learn to adopt reciprocal strategies to establish mutual cooperation in repeated interactions. On the other hand, the recently discovered theory of ZD strategies has found that subjects who use extortionate strategies are able to exploit and subdue cooperators. Although such

Our results thus highlight how power asymmetries can endanger mutually beneficial interactions, and transform them into exploitative relationships. In particular, our results indicate that the extortionate strategies predicted from ZD theory could play a more prominent role in our daily interactions than previously thought.

(ZD je Zero Determinant strategija)

HVALA NA PAZNJI!