Evolution of Diversity and Cooperation

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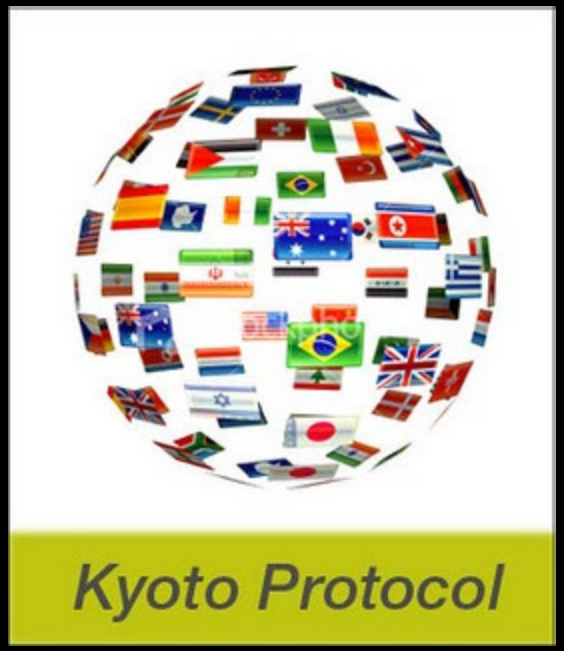
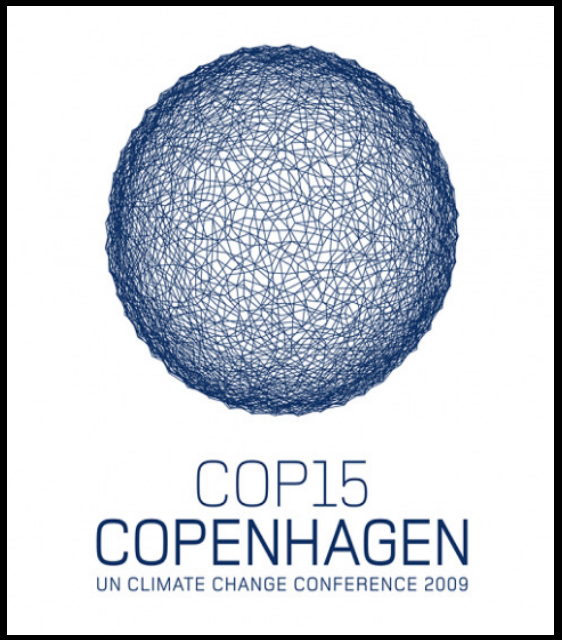
Luis Santaló School, 15th of July, 2013

the challenge of minimizing climate change

cooperation between ALL countries@once ?





1997 (decided)

2005 (into action) (191)

2009

failure of global summits has been attributed to:

- overall perception of risk is too small
- no institution to monitor and sanction those not abiding

the challenge of minimizing climate change

cooperation between SOME countries or SOME peoples ?

Indigenous Peoples' Global Summit on Climate Change

Anchorage, April 2009

The Anchorage Declaration

Regional messages
The Anchorage Declaration
Dialogues with other sectors
Recurring themes

Tiquipaya, Bolivia
April 2010

World People's Conference on Climate Change and the Rights of Mother Earth

Building the People's World Movement for Mother Earth

the challenge of minimizing climate change

cooperation between individuals ?
cooperation between ALL countries ?
cooperation between SOME countries ?
cooperation between SOME peoples ?
cooperation between regions ?

certainly ! **COOPERATION**

	per capita CO_2 emmisions
france / sweden	x
UK / japan	2x
USA	3x

the challenge of minimizing climate change

the cooperation we need to consider involves collective action
public goods games (N-person games)

france / sweden	x
UK / japan	2x
USA	3x

tragedy of the commons

N*-person games** typify the theoretical framework that captures the ***tragedy of the commons

how to escape it ?

a game experiment on climate change

[Milinski *et al.*, *PNAS* 195 (2008) 2291

6 players, 10 rounds

each player : 40 €

contribution in each round : 0 (selfish), 2 (fair) or 4 (altruistic)

cost for saving the planet : 120 €

if Σ contributions $\geq$ 120 €, *planet is saved and each gets away with money left*

if Σ contributions < 120 €, *planet is saved with 10% prob., else all loose everything*

	per capita CO_2 emissions	strategy
france / sweden	x	*altruistic*
UK / japan	2x	*fair*
USA	3x	*selfish*

a game experiment on climate change

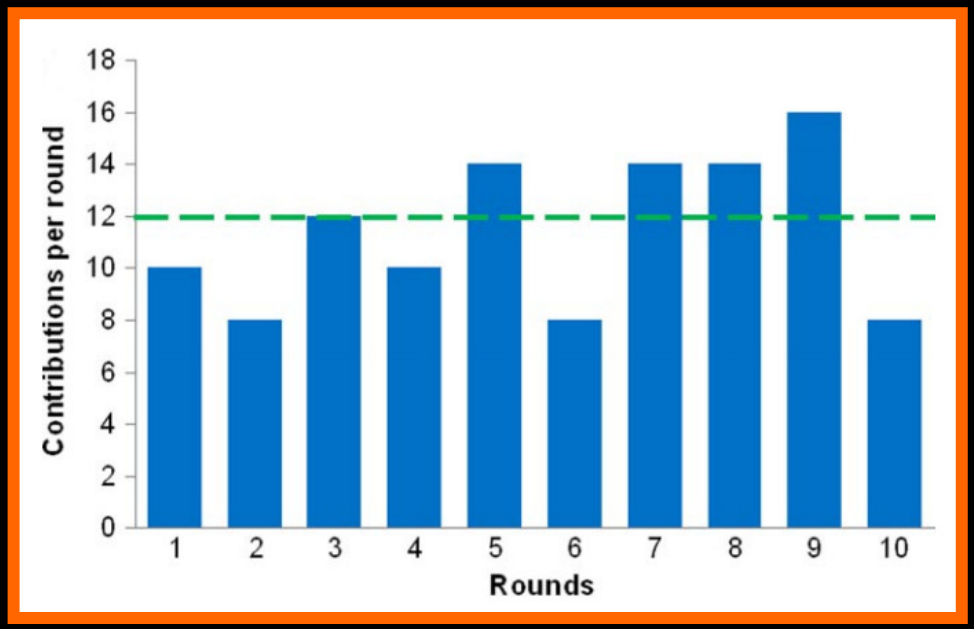
[Milinski *et al.*, *PNAS* 195 (2008) 2291

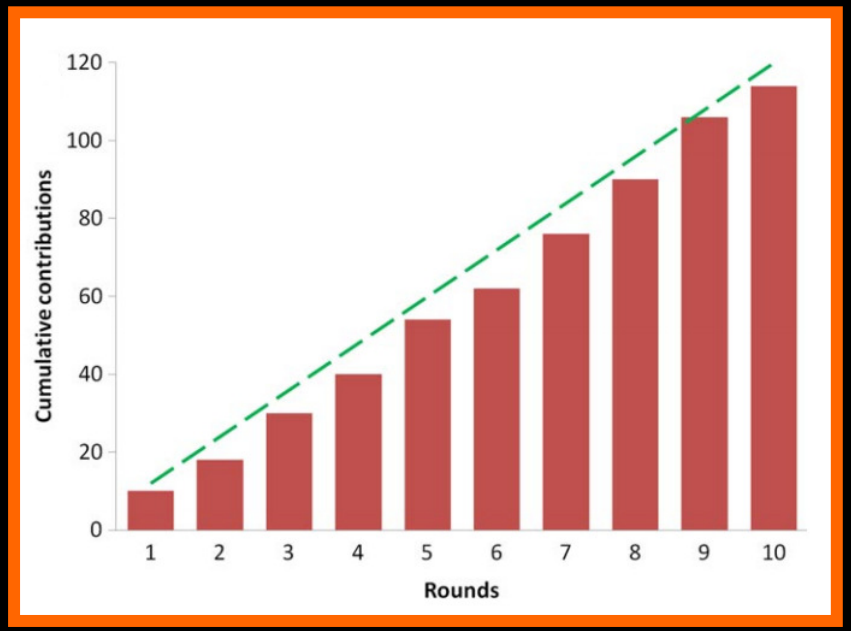
(one) NASH equilibrium : each player contributes 2€ per round

***RESULTS* : 50% of times planet was saved !!!**

50% of times average contribution = 113 € < 120 €

example of a failed attempt :





did altruists feel they had contributed enough ?

what was in the mind of the free riders ?

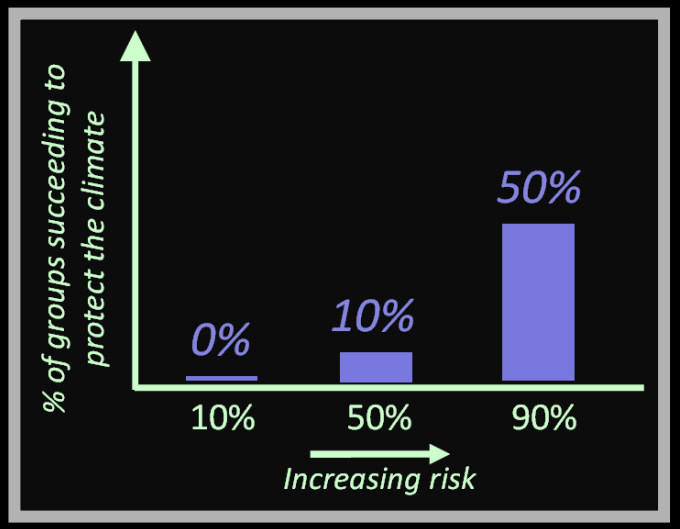
these experiments portray, once more, among other things, the *bounded rationality* of human participants.

more economic experiments on climate change

[Milinski et al., PNAS 105 (2008) 2291]
[Tavoni et al., PNAS 108 (2011) 11825]
[Barrett & Dannenberg, PNAS 109 (2012) 17375]

results

- ***risk*** **plays a very important role**
  [Milinski et al., PNAS 105 (2008) 2291]
- **pre-play communication helps coordinating to meet *M***
  [Tavoni et al., PNAS 108 (2011) 11825]
- **uncertainty in *M* may destroy cooperation**
  [Barrett & Dannenberg, PNAS 109 (2012) 17375]



message from the game experiments on climate change

perceived risk of disaster ↗ *cooperation* ↗

rationality of players is not an argument

individuals revise their strategy along the way

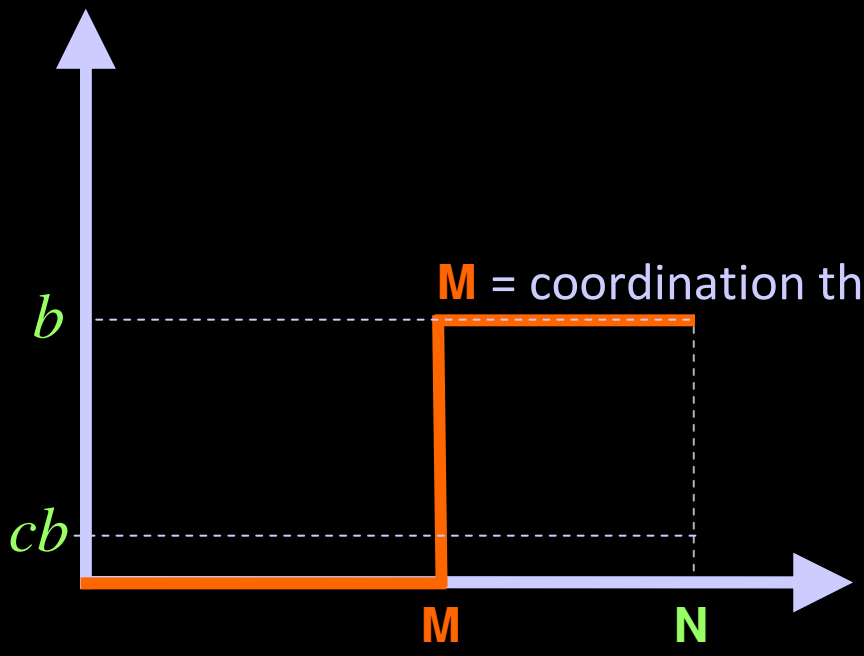
drawbacks from the game experiments on climate change

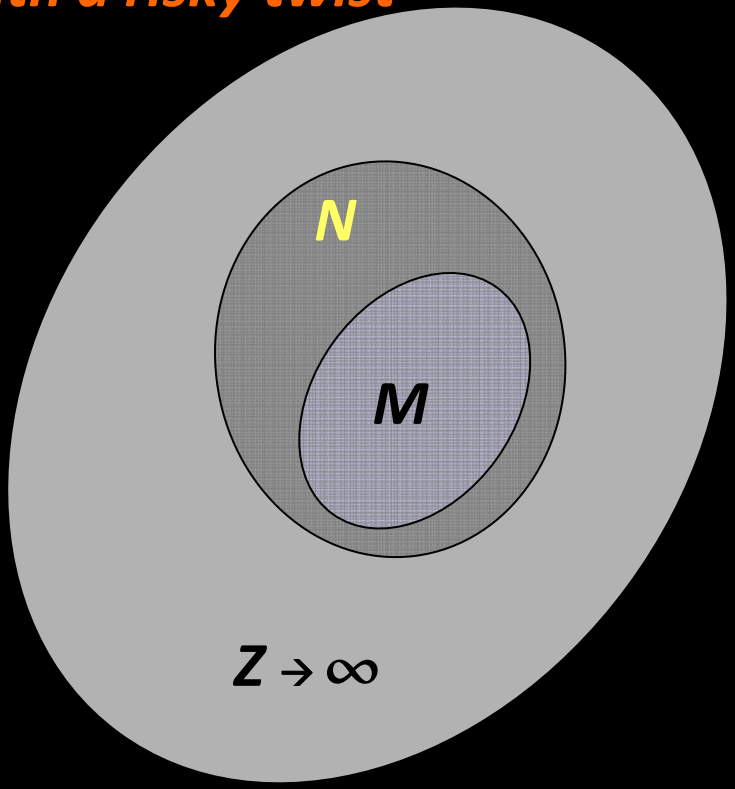
small groups . . . and only 1 group size . . .
finite & small time horizon for investments
repeated game with fixed number of rounds . . .

we can say nothing for different population sizes
we can say nothing for different group sizes
how does this apply to the world summits on climate change ?

an *evolutionary* approach to climate change

N-person Coordination game . . . *with a risky twist*





Cooperators **contribute an amount** cb **(cost) to a** ***public good which helps reducing GHG emissions***

Defectors **do not contribute; If** Σ ***cb*** $<$ ***M*** **all loose everything with probability** ***r***

otherwise : everyone keeps all they have

[Santos & Pacheco, PNAS 108 (2011) 10421-10425]

an *evolutionary* approach to climate change

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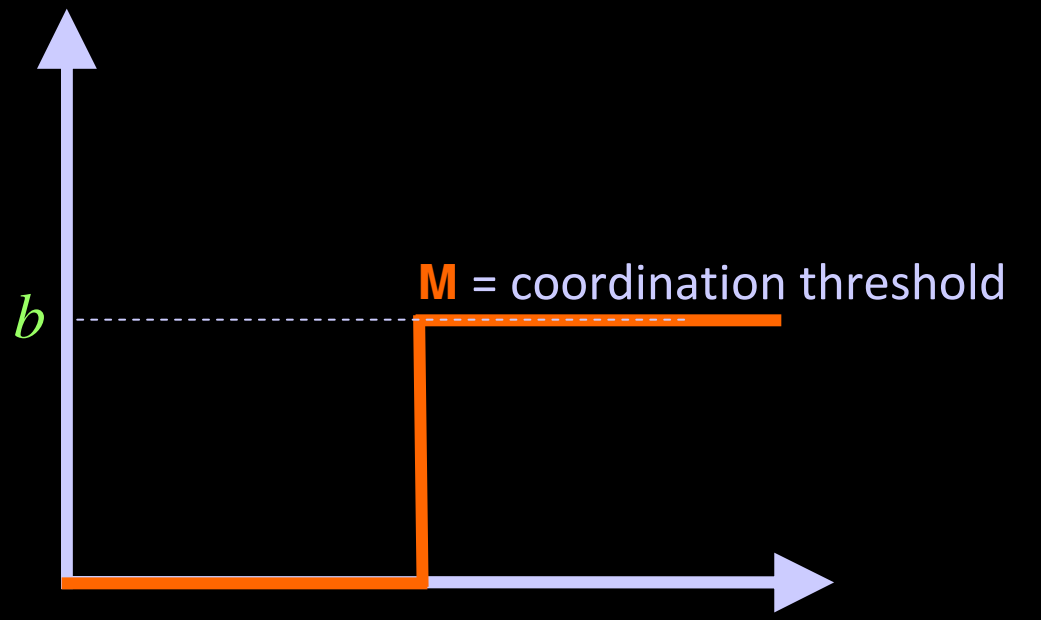

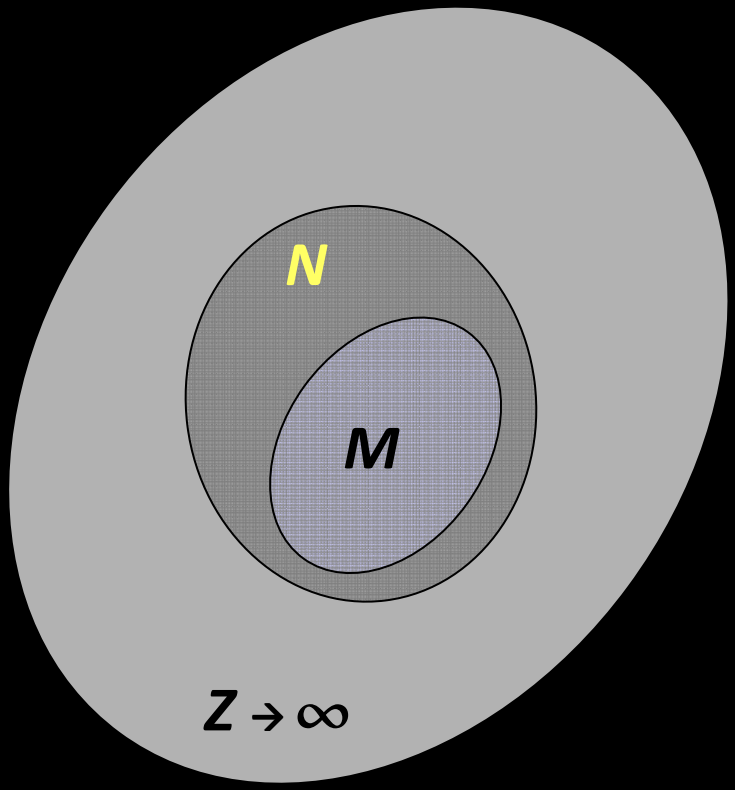

- Evolution → *REPLICATOR DYNAMICS*
- Groups → *WELL-MIXED populations*

evolutionary dynamics of N-person coordination games

JmP, F. C. Santos, M. Souza, B. Skyrms, Proc. Royal Society B 276 (2009) 1655
M. Souza, F. C. Santos, JmP, J. Theor. Biol. 260 (2009) 581-588

$$\dot{x} = x\,(1-x\,)(f_C(x\,) - f_D(x\,))$$

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for *N*-person games in well-mixed populations we have

$$f_D(x) = \sum_{k=0}^{N-1} \binom{N-1}{k} x^k (1-x)^{N-1-k} P_D(k)$$

$$f_C(x) = \sum_{k=0}^{N-1} \binom{N-1}{k} x^k (1-x)^{N-1-k} P_C(k+1)$$

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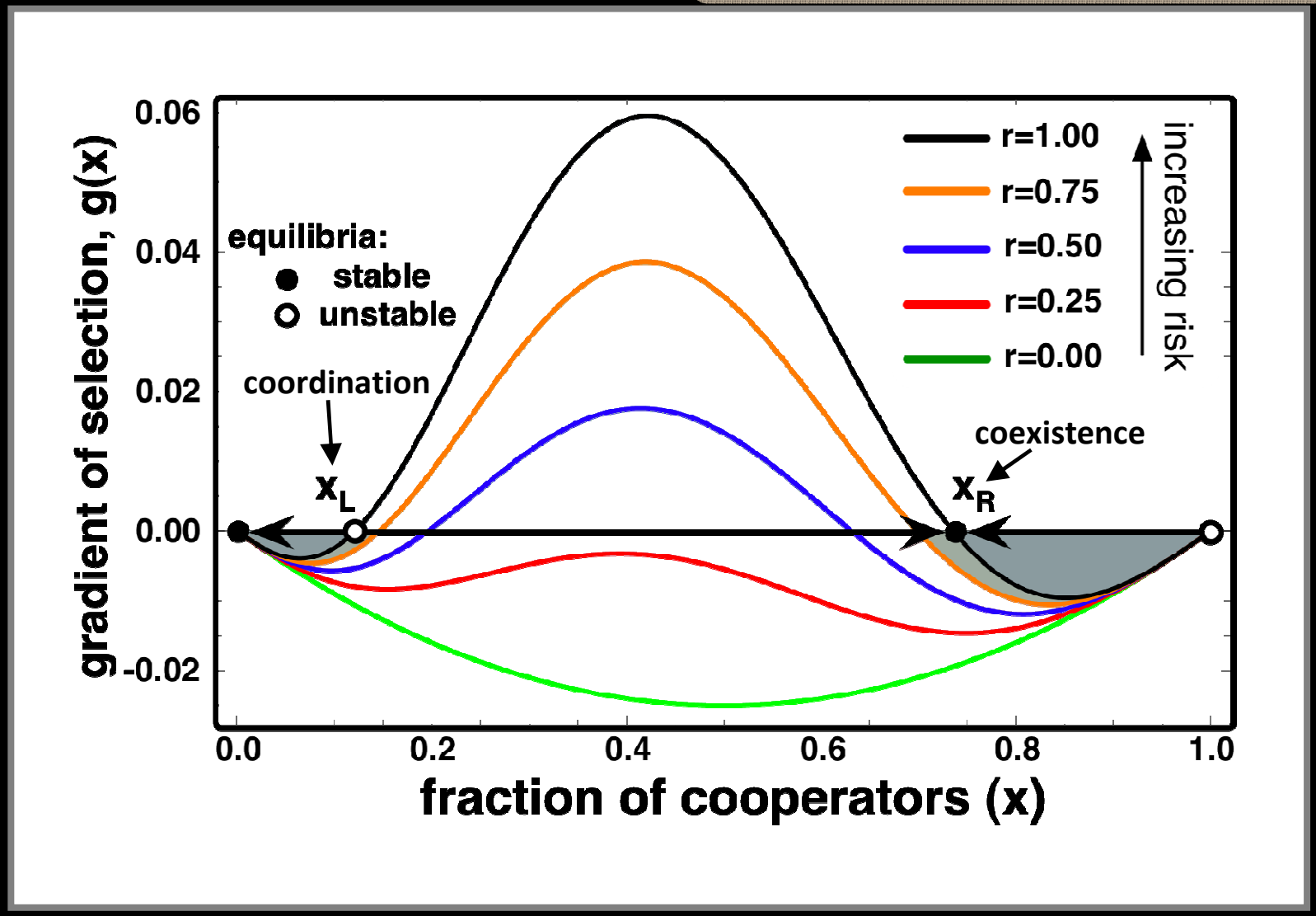
$$f_C(x)=\sum_{k=0}^{N-1}\binom{N-1}{k}x^k(1-x)^{N-1-k}P_C(k+1)$$

we are assuming ***infinite*** populations; whenever populations are ***finite***, binomial sampling is replaced by hypergeometric sampling and the replicator dynamics is also replaced by its finite population ***stochastic*** analogue.

results

risk-dependence

$$Z \to \infty ; N = 6 = 2M ; c = 0.1b$$



results

risk-dependence

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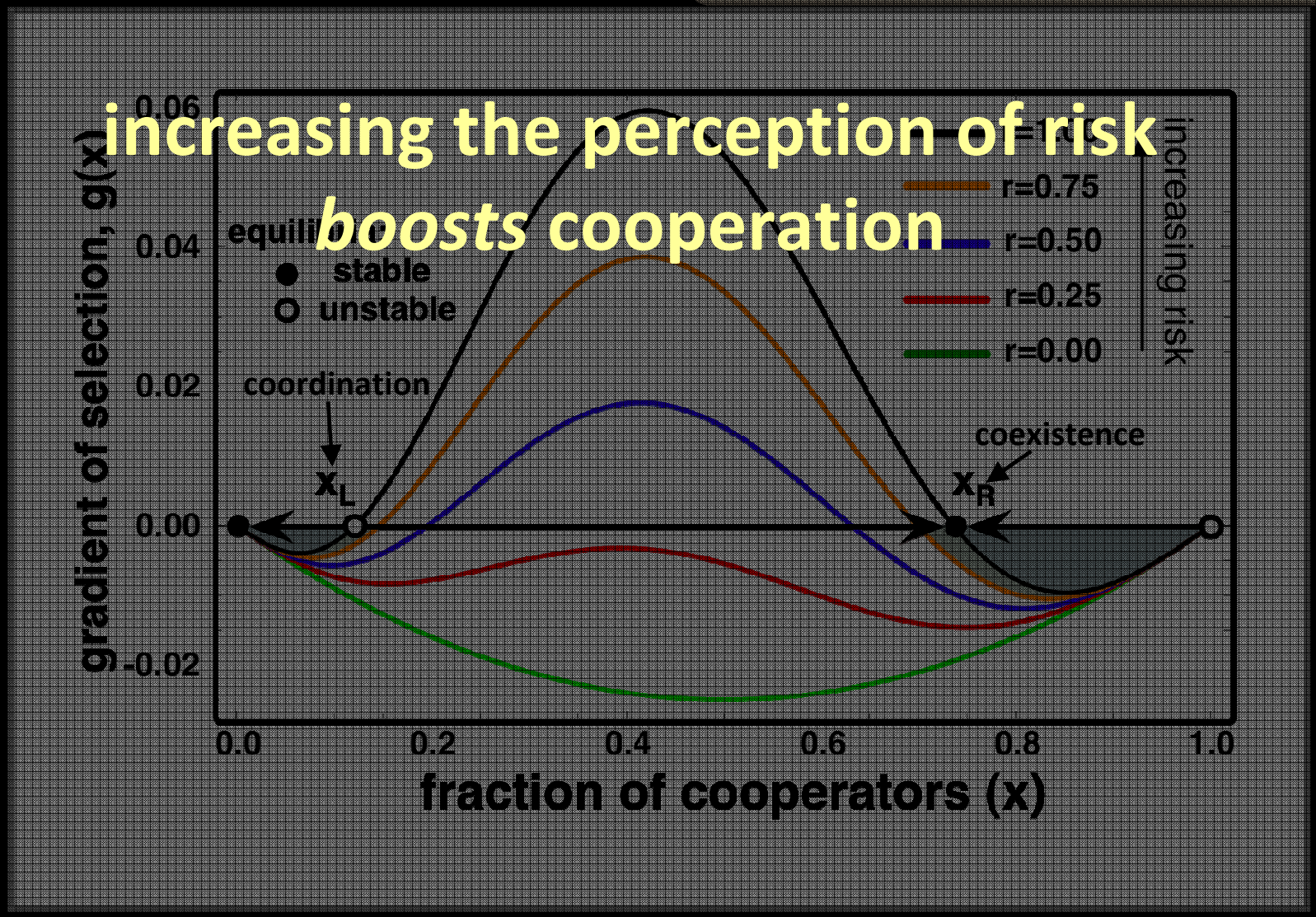
increasing the perception of risk *boosts* cooperation



results

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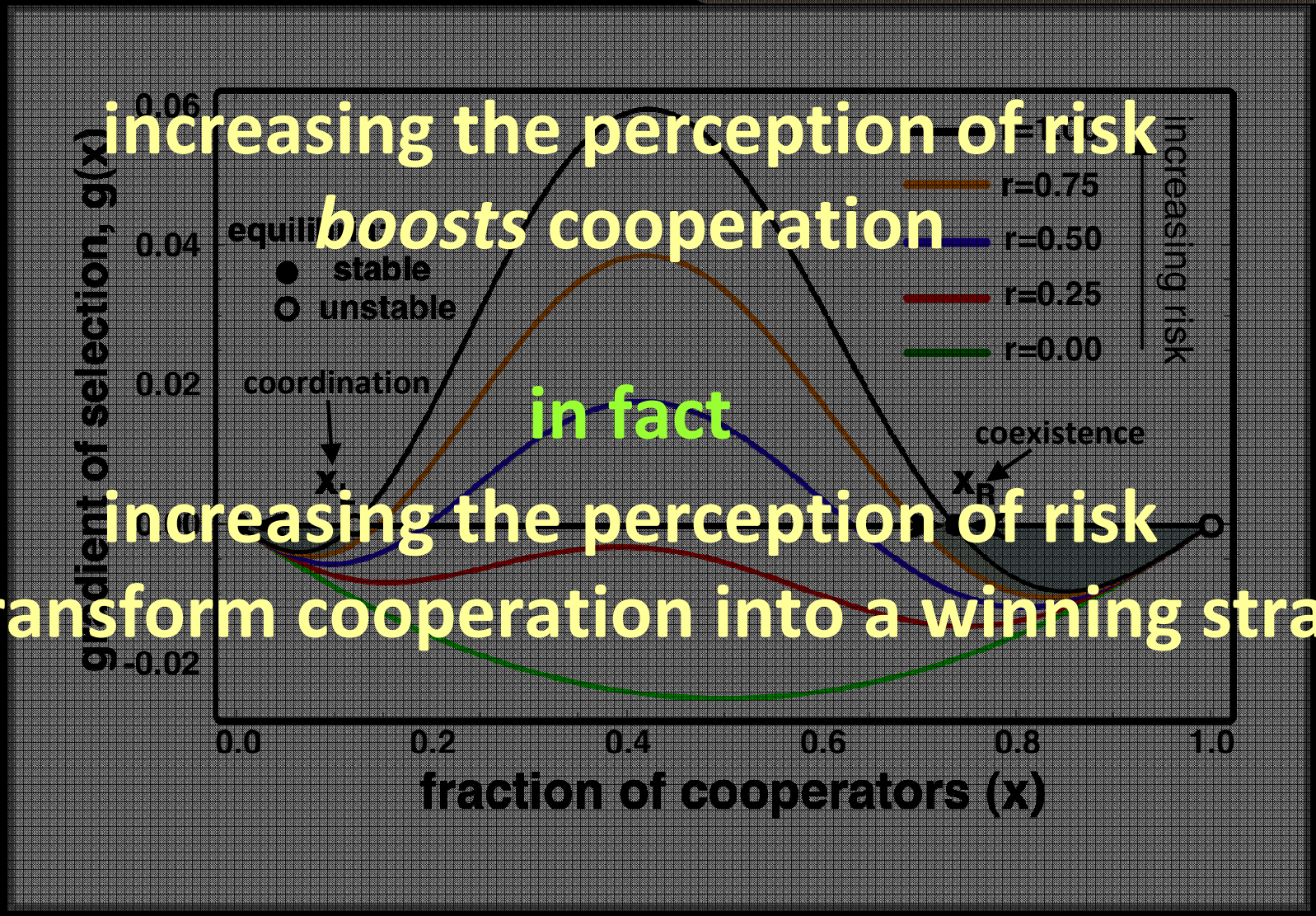
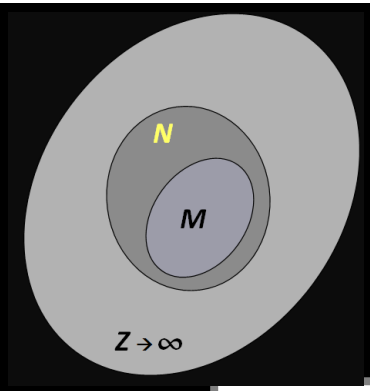


increasing the perception of risk *boosts* cooperation

in fact

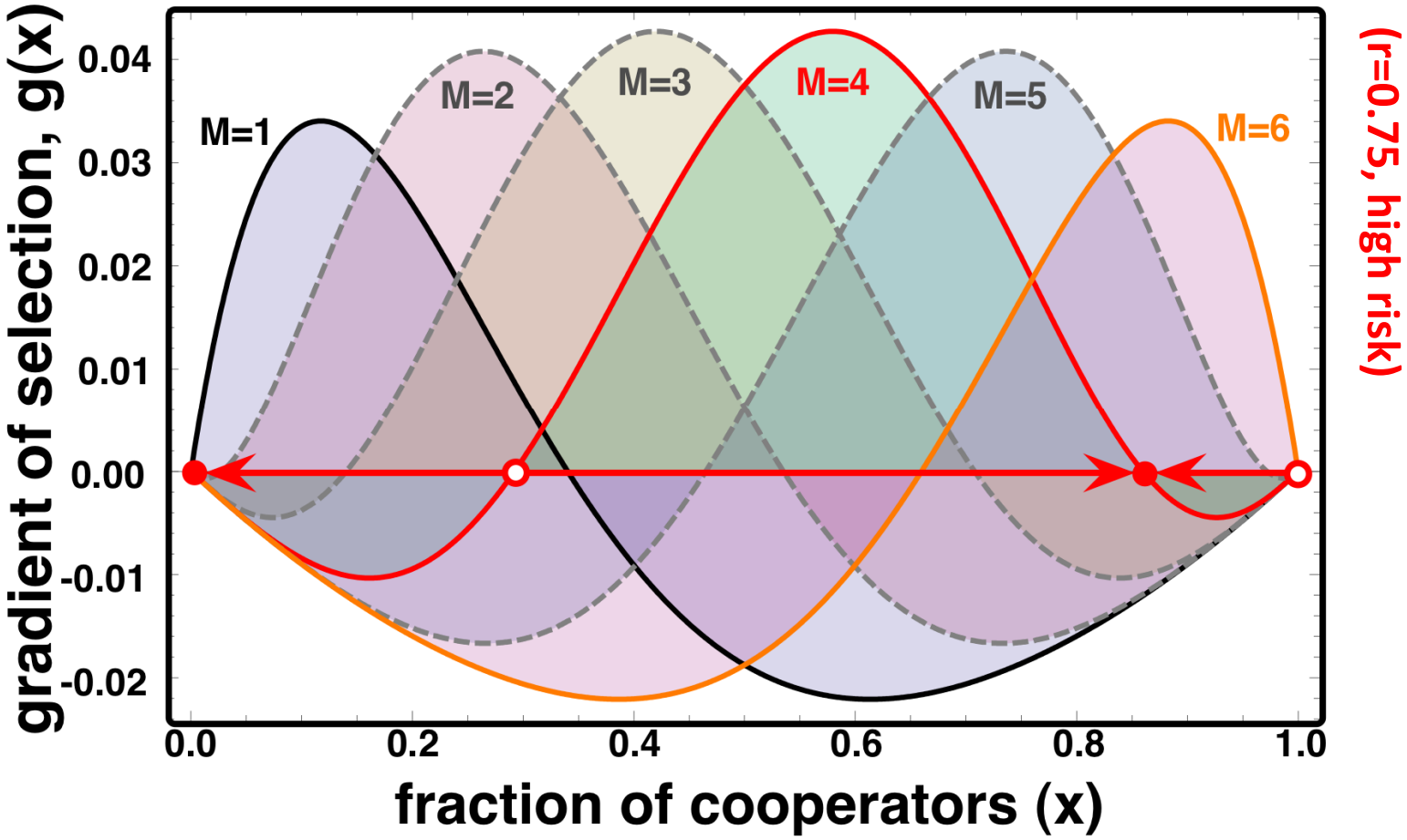
increasing the perception of risk may transform cooperation into a winning strategy

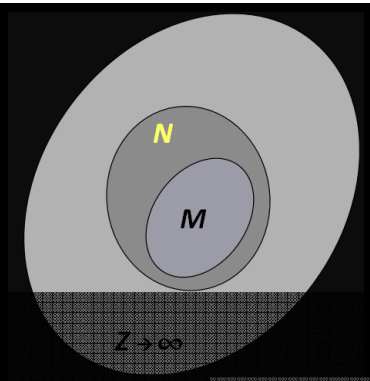


results

threshold-dependence

$$Z \to \infty ; N = 6 ; c = 0.1b$$





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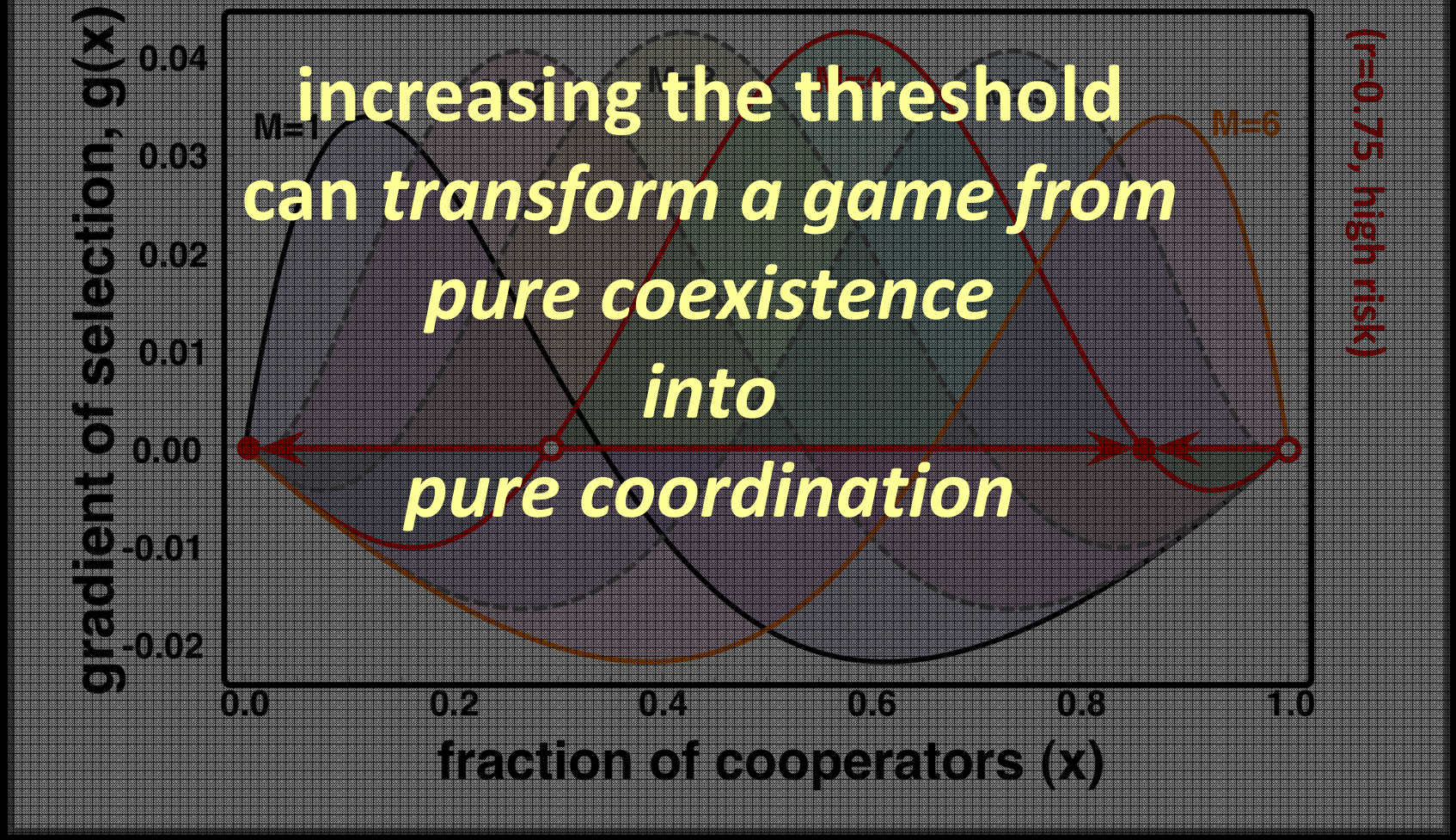
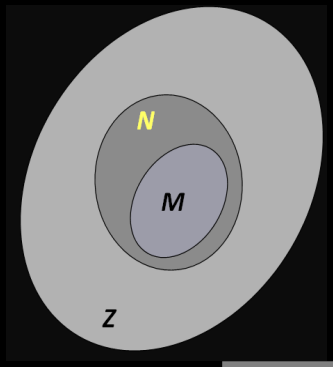


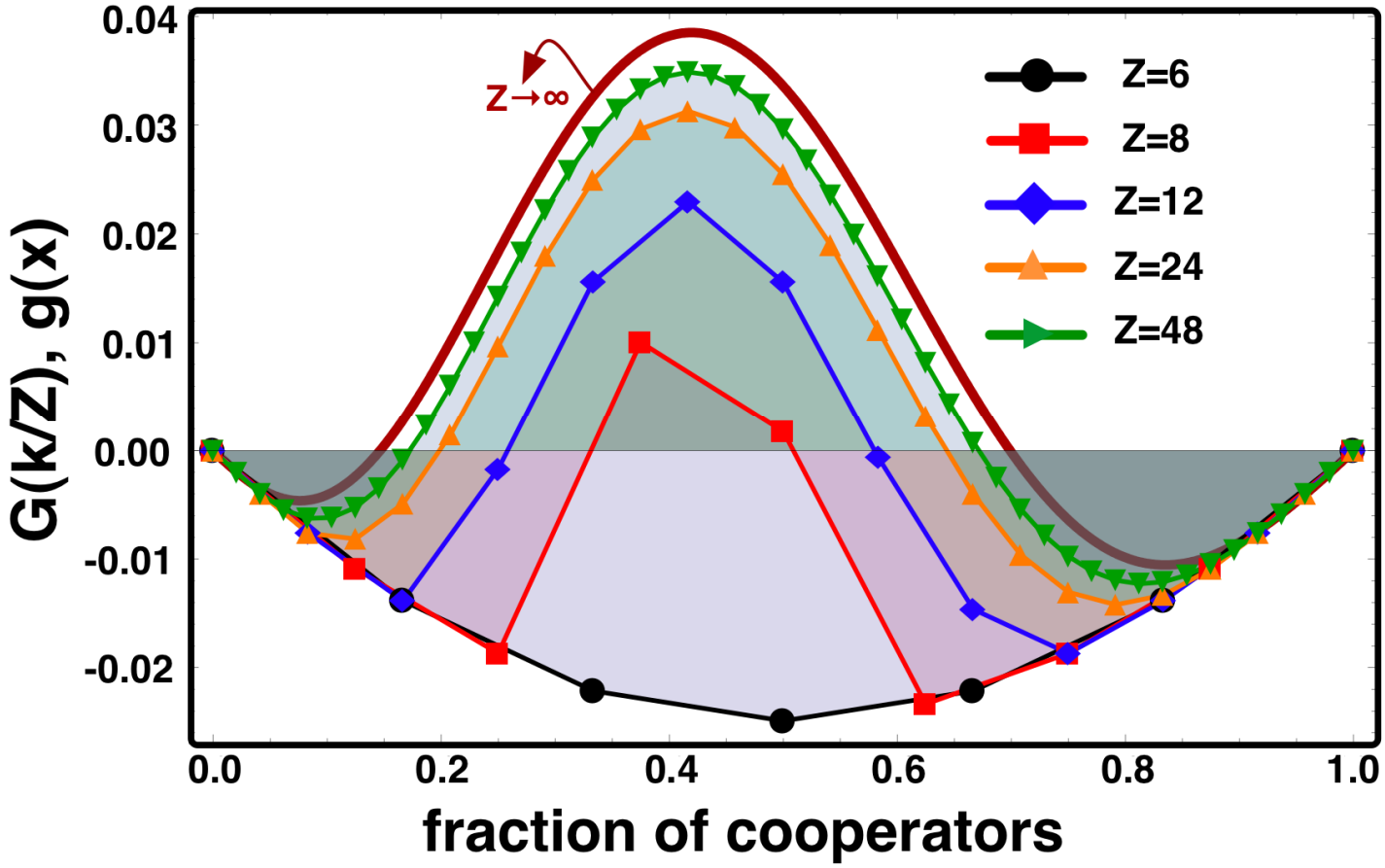


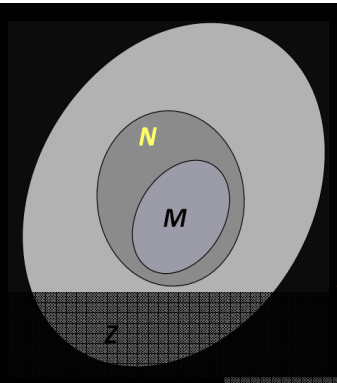
results

population-size dependence

$$N = 6 = 2M; c = 0.1b$$

(r=1.0, highest risk)





results

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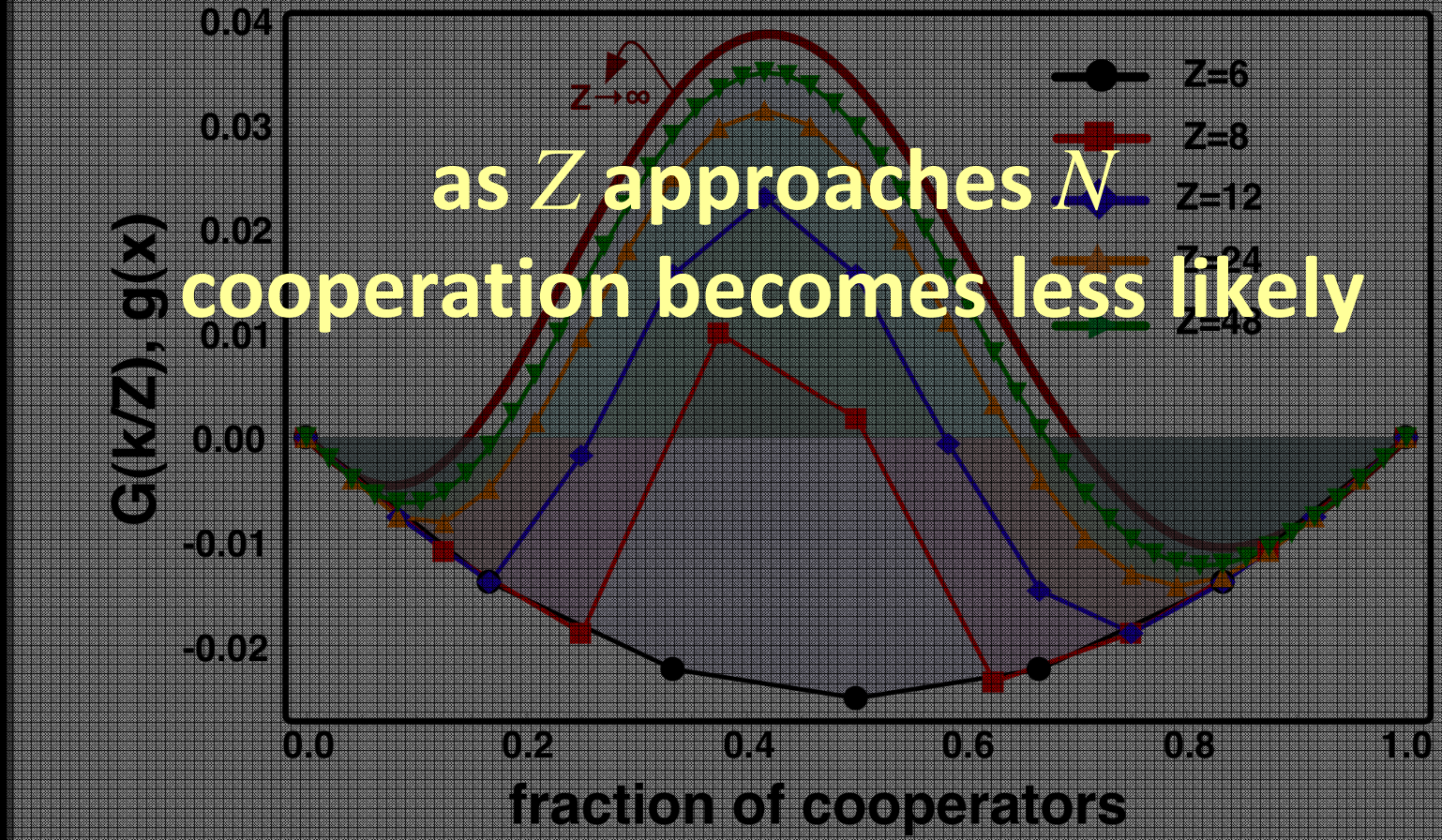
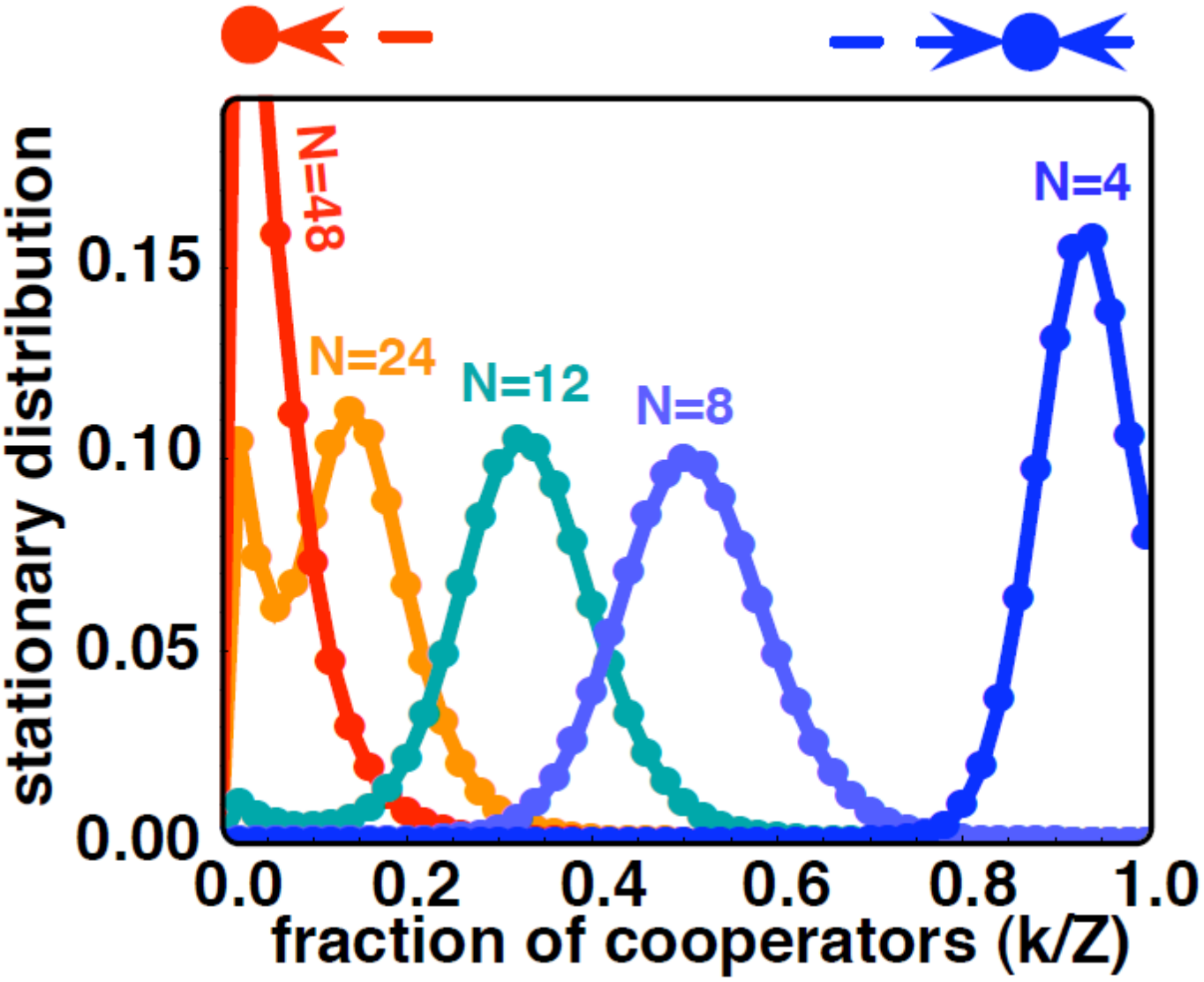


as Z approaches N
cooperation becomes less likely

results

what about group size ?

$$Z = 50; M = 3; c/r = 0.15$$



summary

cooperation ↑ when :

- perception of risk ↑
- group size ↓
- threshold ↑
- population size ↑

summary

cooperation ↑ when :

perception of risk ↑

group size ↓

threshold ↑

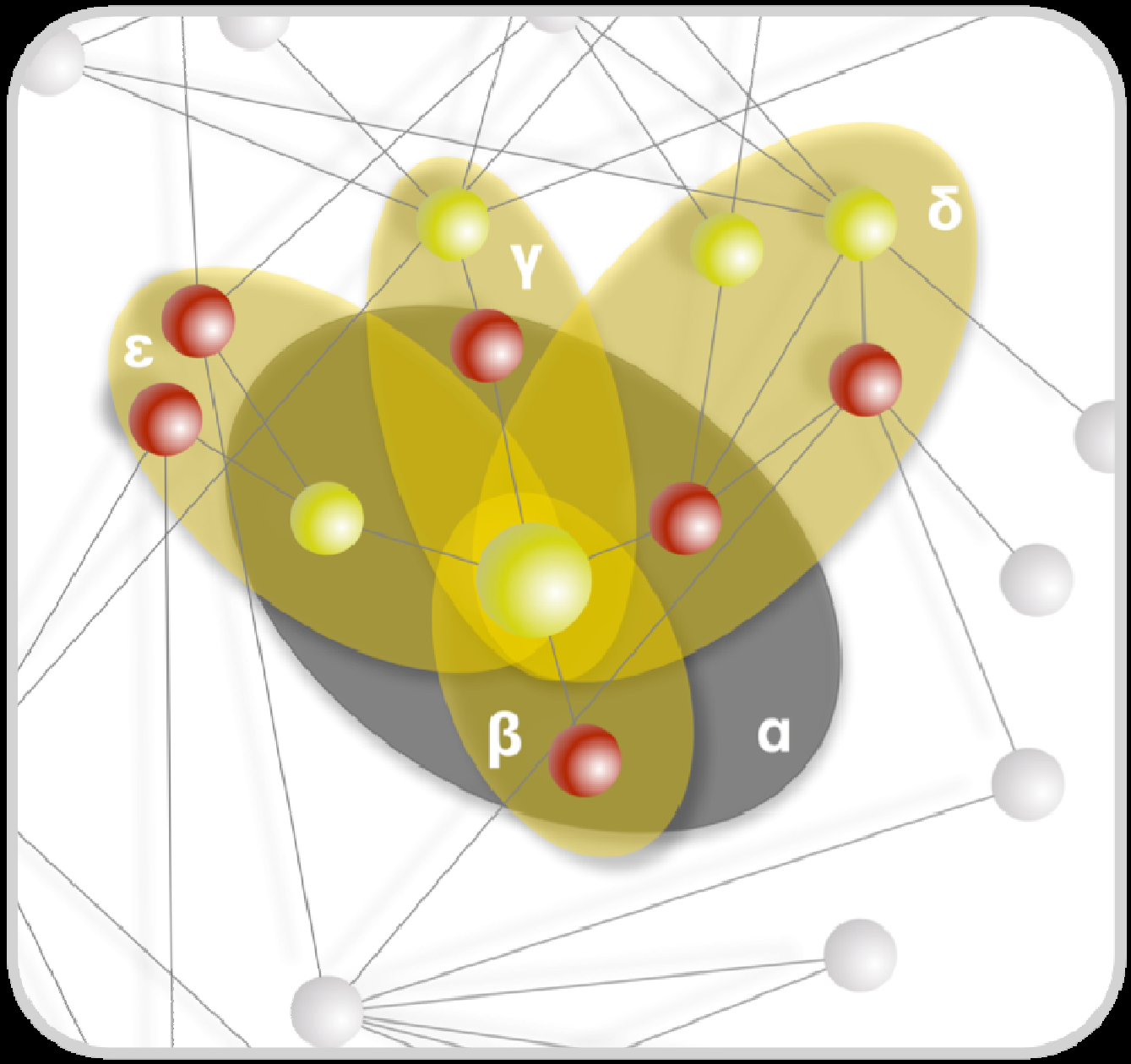
population size ↑

can we further improve cooperation ?

additional mechanisms

- ***networked*** **public goods games of cooperation**
- **setting up *sanctioning institutions* – in which way ?**

networked public goods games of cooperation



networked public goods games of cooperation

how to define the networks ? some ideas . . .

networks could be defined based on *groups of countries* bound by common interests, such as

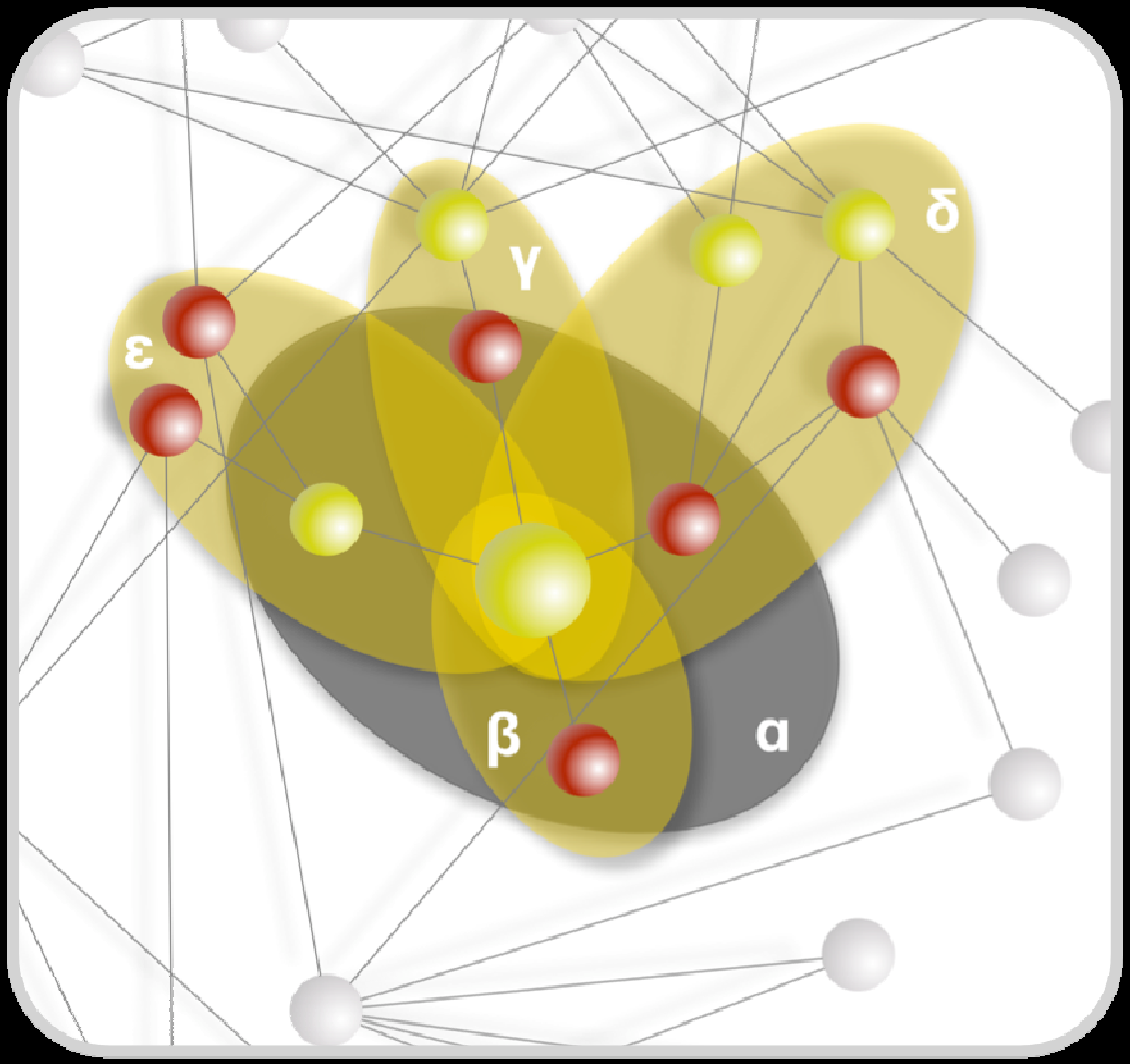
— alternative forms of energy
— similar means of managing CO_2 emmisions
— joint interest in local commons
— *etc* . . .

or *groups of regions* bound by common interests
(ex: California in *USA*, Catalonia in *Spain*, Bavaria in *Germany*, etc.)

Introducing diversity

Collective risk games in structured populations

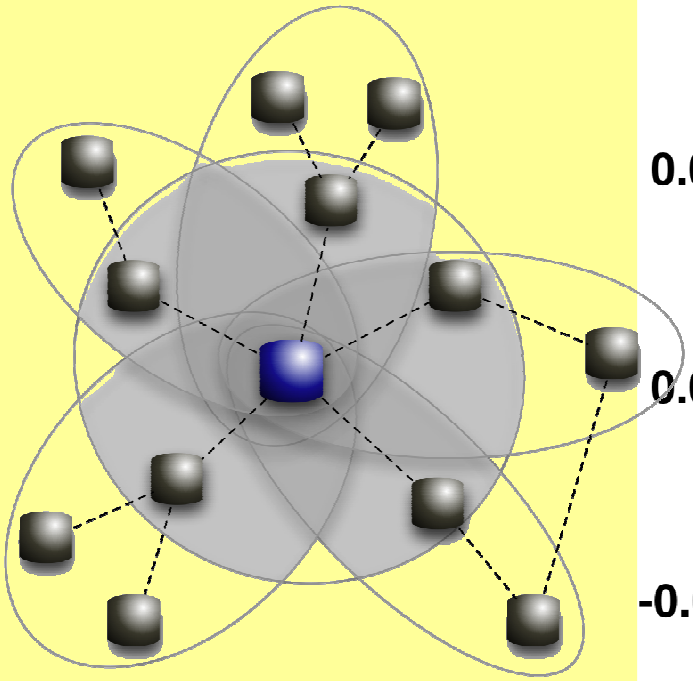
each neighborhood defines a game/group.

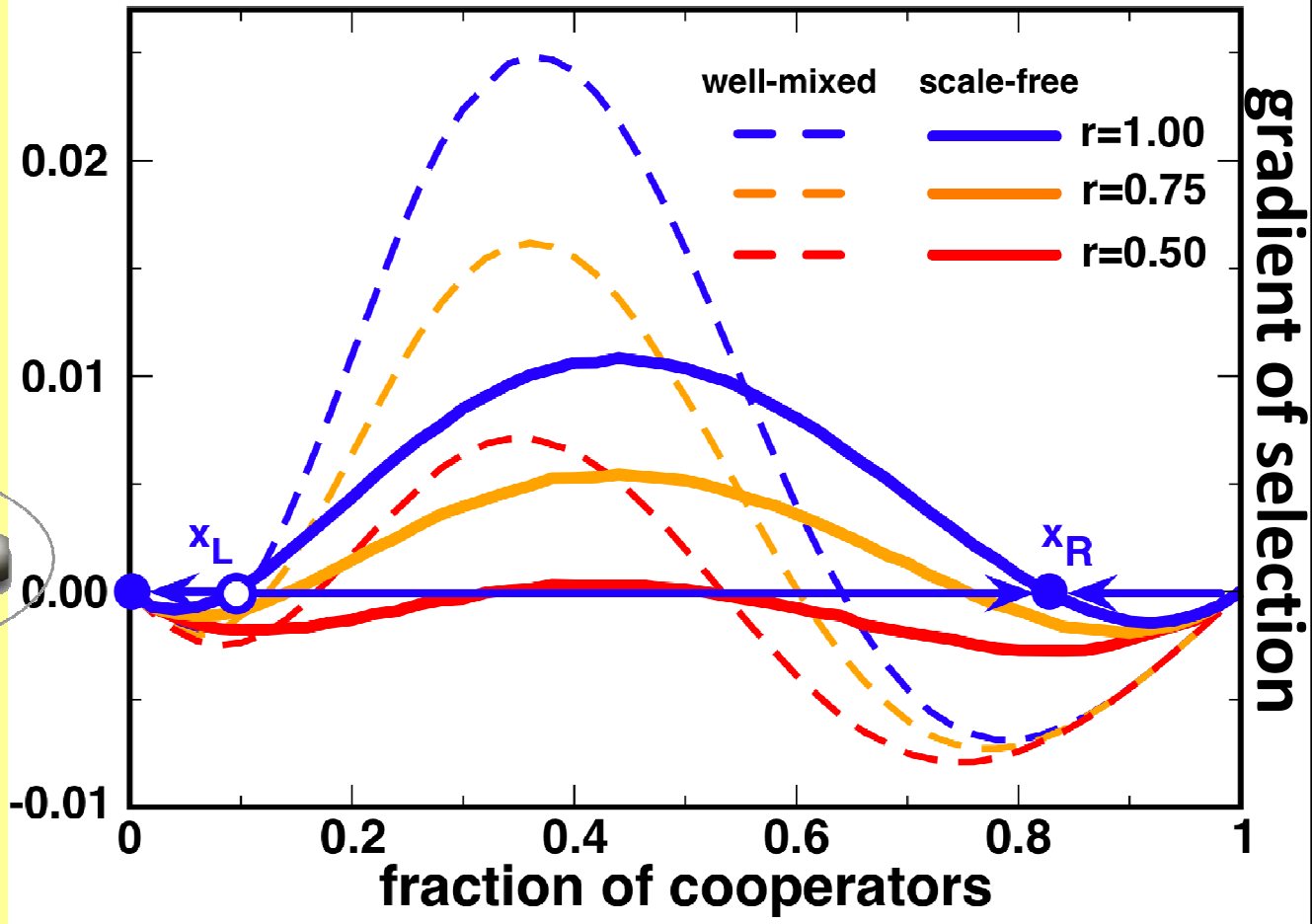


[FC Santos, MD Santos and JM. Pacheco, Nature 454, 213-216 (2008)]

results

The role of diversity (numerical results)



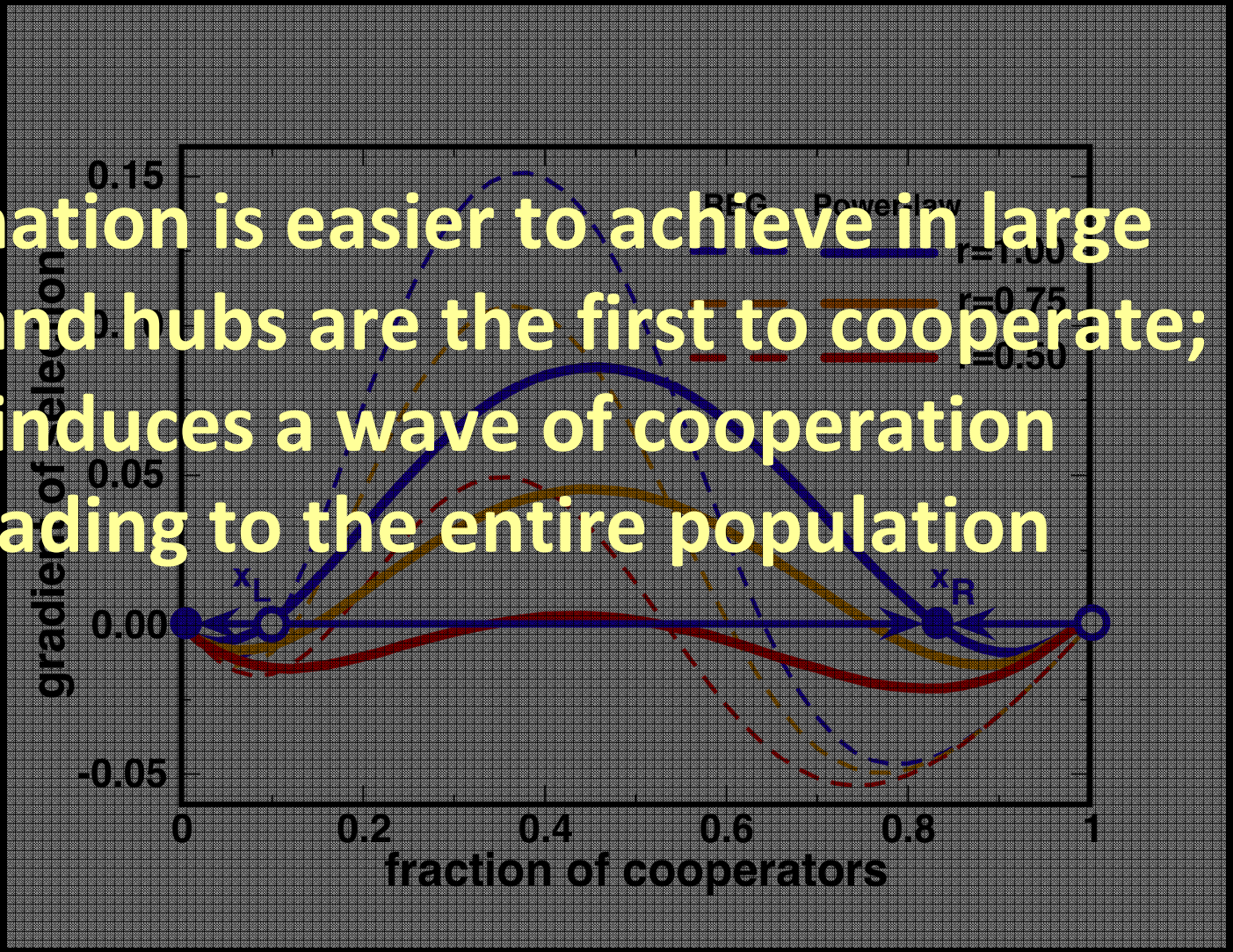


$$Z = 500; < N >= 7; N_{\min} = 4; M = 3; c = 0.1b$$

results

The role of diversity (numerical results)

coordination is easier to achieve in large groups, and hubs are the first to cooperate; this induces a wave of cooperation spreading to the entire population



our EGT approach suggests

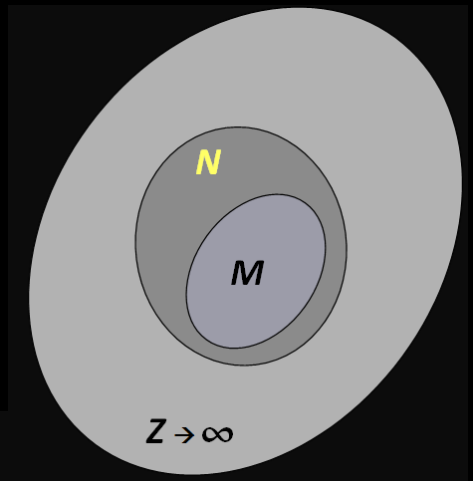
- many small groups (better: in a diverse set of groups)
- high perception of risk
- stringent thresholds to meet goals (high M)
- exploit the heterogeneous nature of the interaction structure.

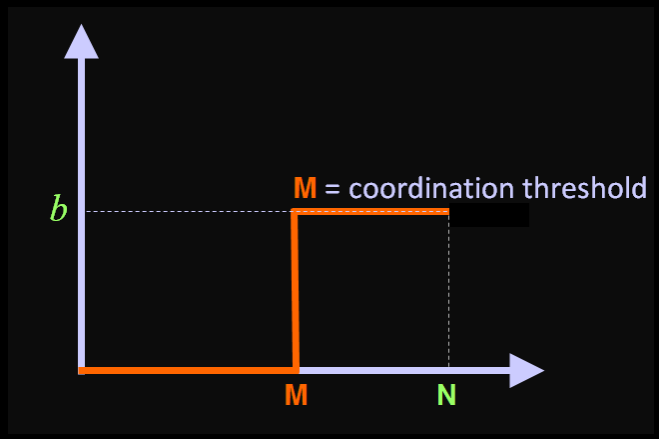
[Santos & Pacheco, PNAS 108 (2011) 10421-10425]

and what about sanctioning institutions ?

same N-person Coordination game . . . with a risky twist

[Vasconcelos, Santos & Pacheco, Nature Climate Change (2013) in press]





group size is ***N***;

***C*s always** contribute to the public good

***D*s never** contribute to the public good

***P*s** also contribute to the public good

also contribute a *punishment tax* π_t to an institution which will impose a fine Δ to all ***D*s** whenever the number of ***P*s** exceeds n_P

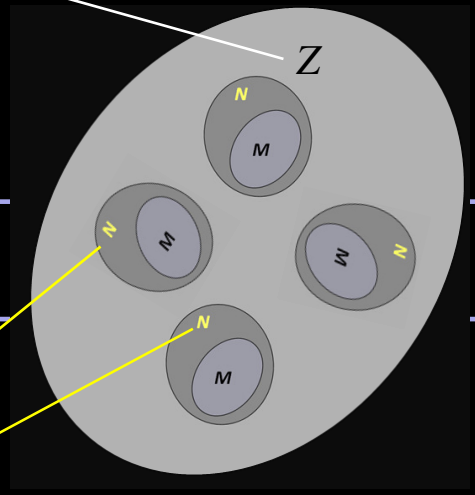
this, however, **does not tell the whole story** :
Institutions may be ***local*** or ***global***, and this affects the way in which sanctions are applied.

global versus *local* institutions

global **institution : in this case**

$$0 < n_P \leq Z$$

and sanctions affect *all D*s in the population



local **institutions : in this case**

$$0 < n_P \leq N$$

and sanctions affect *all D*s in the group in which the punishing thresholds were surpassed

global versus *local* versus *lack of* institutions

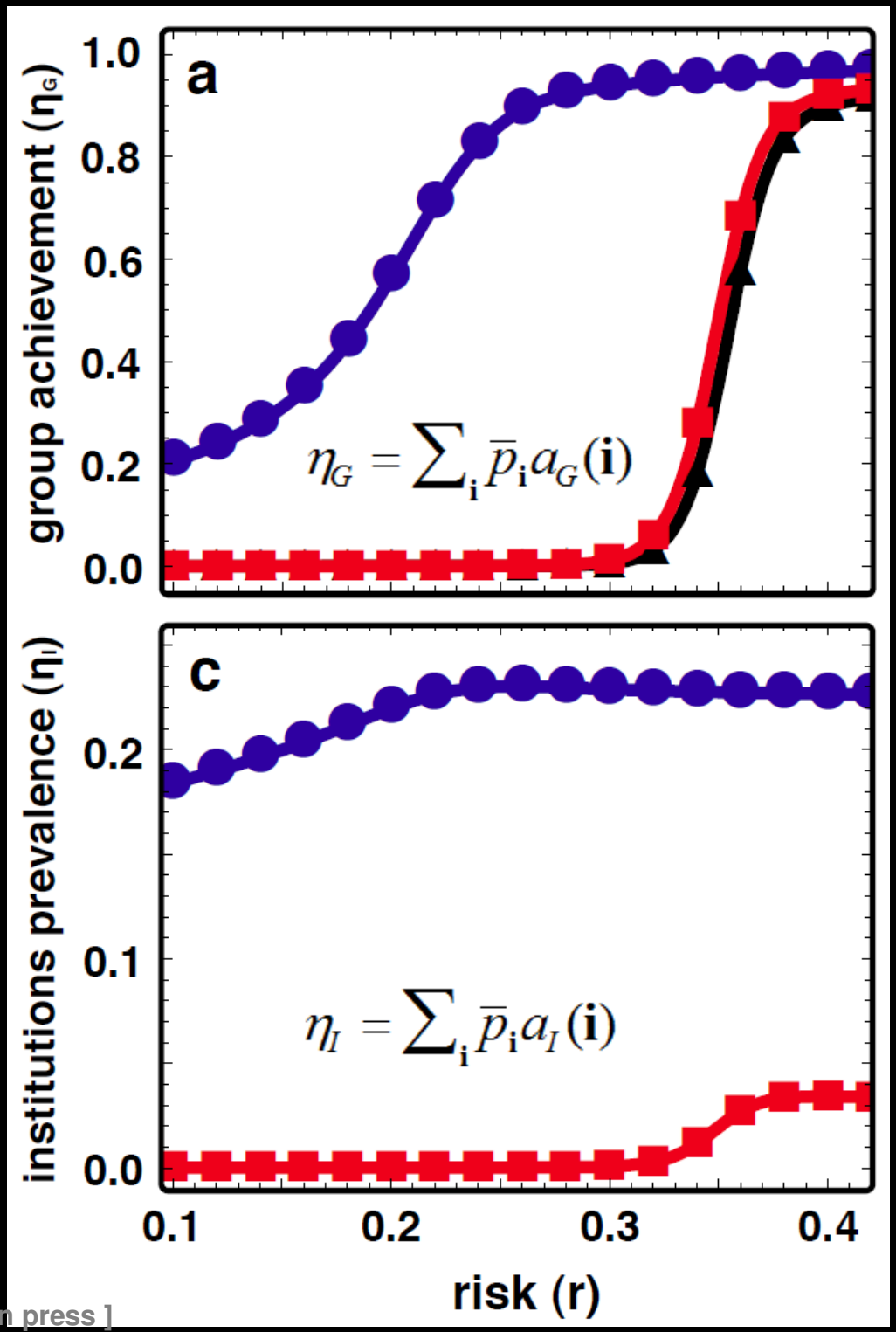
local institutions

global institutions

without institutions

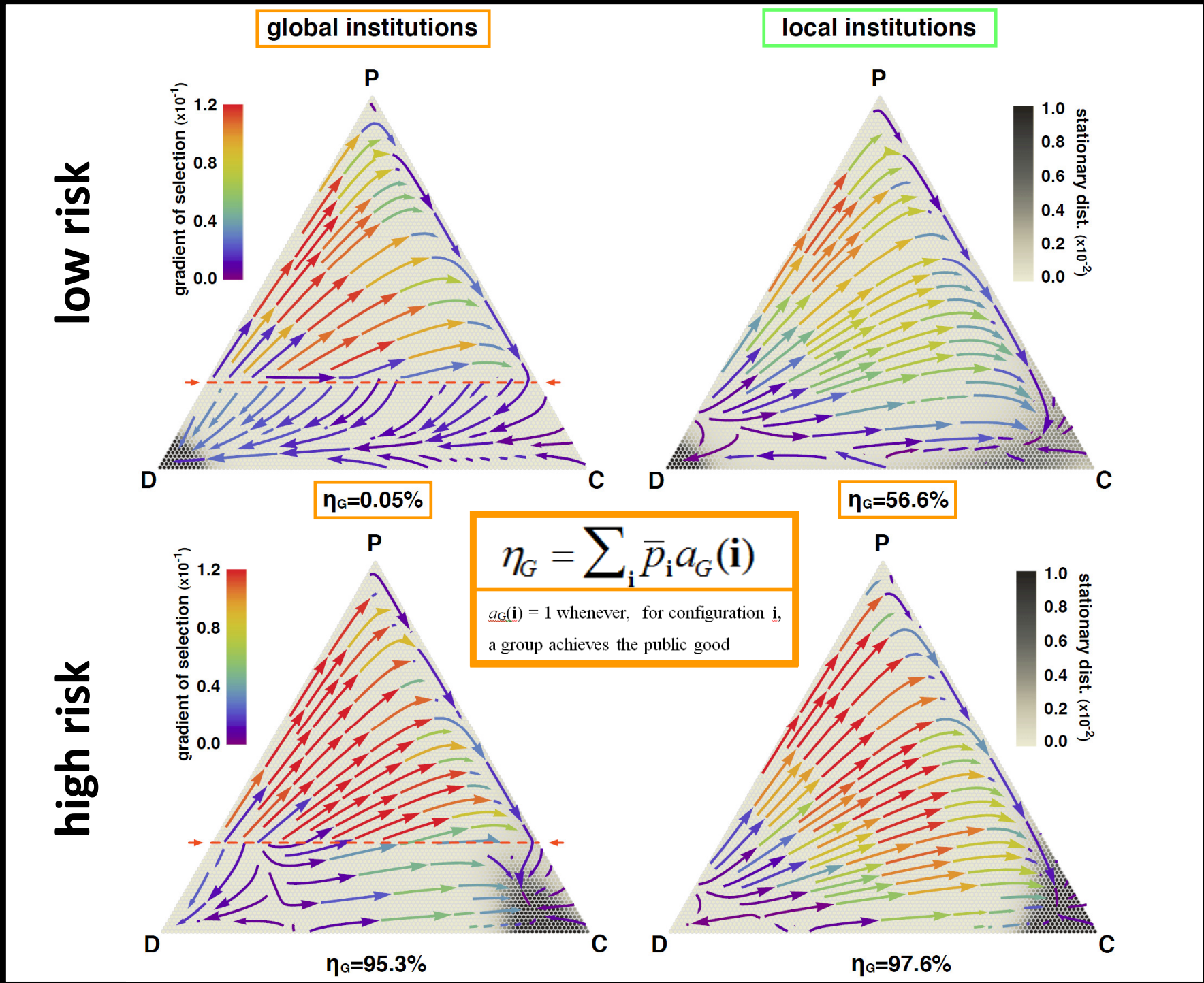
$a_G(\mathbf{i}) = 1$ whenever, for configuration **i**, a group achieves the public good

$a_I(\mathbf{i}) = 1$ whenever, for configuration **i**, an institution is formed



[Vasconcelos, Santos & Pacheco, Nature Climate Change (2013) in press]

global versus *local* institutions



conclusions

the results of our model suggest that coordinating for a common good is *best* achieved by

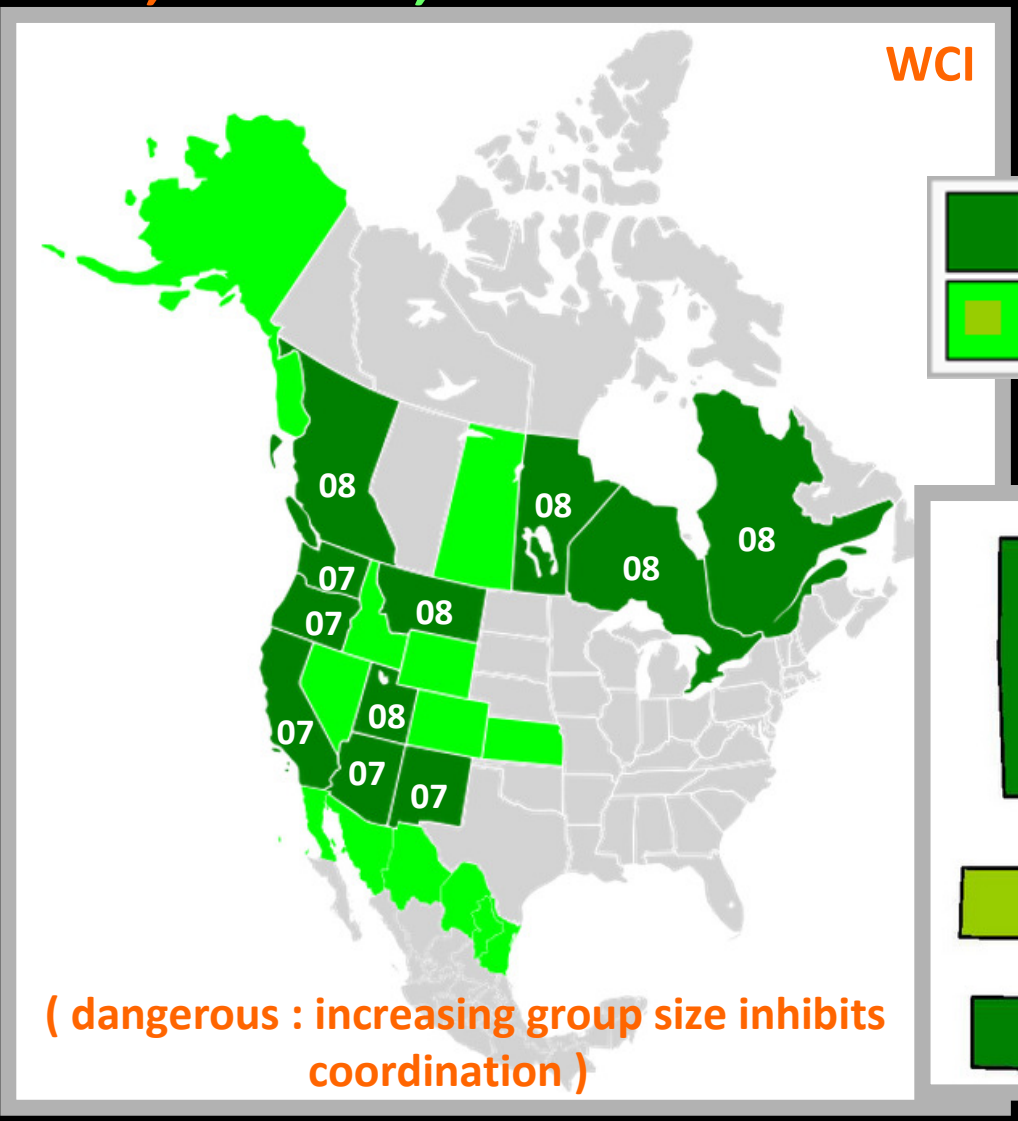
- using a polycentric approach involving many small groups
- making perception of risk (realistically) *high*
- imposing stringent thresholds to meet goals
- exploiting heterogeneous nature of the interaction network
- setting up *local* institutions@group-level, which *play a crucial role* when perception of risk is small;

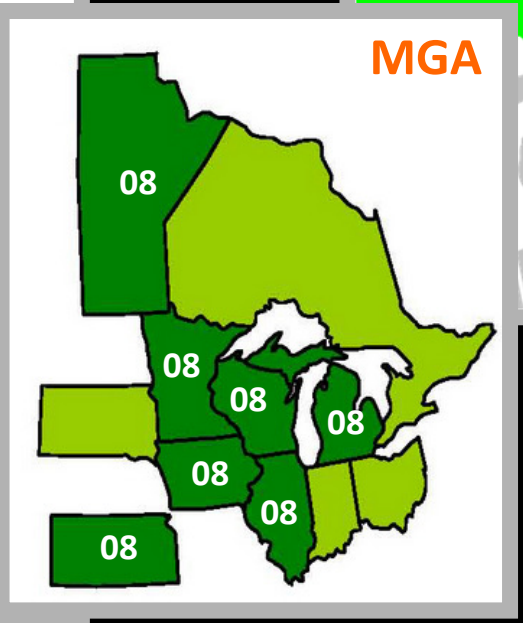
— *global* institutions (such as the **UN**) are essentially *ineffective* in promoting cooperation

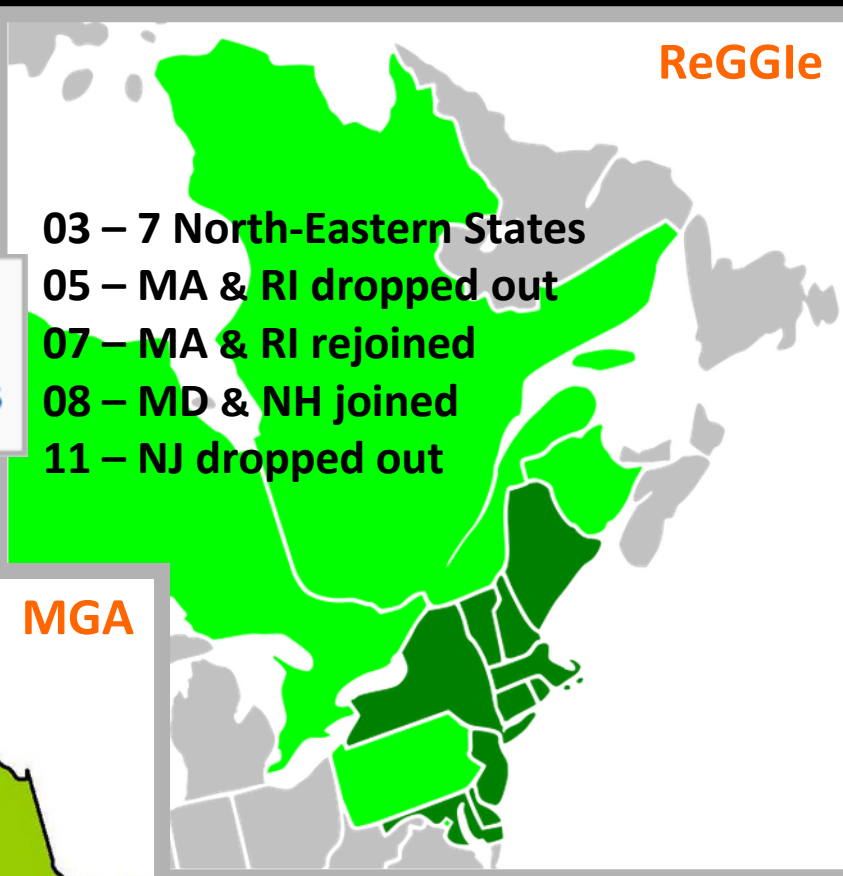
— is this *utopia* ? any feasibility for *bottom-up* attempts ?

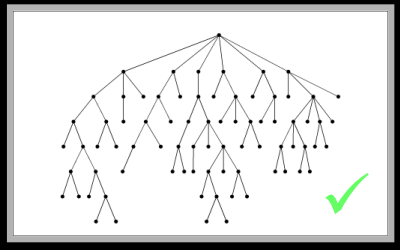
alternatives to minimize climate change impacts

WCI, ReGGIe, MGA







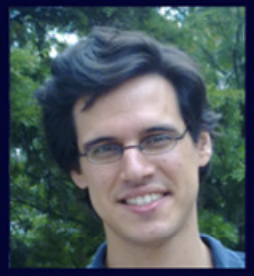


these state/province initiatives, regionally based, aim at aggregating into a wider and stronger structure, called NORTH AMERICA 2050

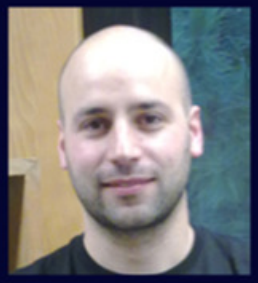
thank you!

atpgroup

http://www.ciul.ul.pt/~ATP/



Francisco C. Santos
Sara Encarnação
Ana Ribeiro



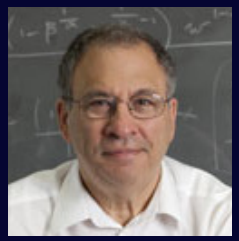
Pedro Neves
Flávio Pinheiro
Vítor Vasconcelos

a melting pot of cooperation across disciplines

atpgroup : collaborators




Brian Skyrms @Irvine & Stanford, USA
David Dingli @Mayo Clinic, USA
Robert Austin @ Princeton, USA
Lucio Luzzatto @ Inst. Tumori, Italy

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Tom Lenaerts @ULBrussels, Belgium
Juval Portugali @U-Telaviv, Israel
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