Network dependence of strong reciprocity

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Network dependence of strong reciprocity

- Games
- Nash equilibria. Some examples
- Nash equilibria and experimental games
- Homo Oeconomicus versus Homo Reciprocans. Strong reciprocity
- Emergence of strong reciprocity. The Bowles-Gintis model
- Network dependence of strong reciprocity
- Conclusions

Games

- **Game theory:** Study of multi-person decision problems influencing one another's welfare
- Economics, Biology, Social Sciences, Communication

Games

- **Mechanism**:
  Cooperation or competition to reach a best goal state (from the cooperative or individual point of view)

Games

- Static Games and Dynamic Games
- Pure versus Mixed strategies
- Complete versus Incomplete information
- Strategy s_K dominated by s_P if
  $P(s_1,s_2,\ldots,s_p,\ldots,s_n)>P(s_1,s_2,\ldots,s_k,\ldots,s_n)$
  for all $s_1,s_2,\ldots,s_n$
- Iterated elimination of dominated strategies

Games - Nash equilibrium

- $(s_1,s_2,\ldots,s_k,\ldots,s_n)$ is Nash equilibrium if $P(s_1,s_2,\ldots,s_k,\ldots,s_n)>P(s_1,s_2,\ldots,s_k',\ldots,s_n)$ for all s_k'
- No player can improve his payoff by changing his strategy, when the strategies of the other players are fixed
- Every N-player game, with finite strategies, has at least one Nash equilibrium, in pure or mixed strategies
- In economy, Nash equilibrium ⇔ Self-interested rational decisions (Homo Oeconomicus)

Nash equilibria. Some examples

- Town or village ?
  Friend or foe ?

	T	V
T	1,1	(2,5)
V	(5,2)	-1,-1

Nash equilibria. Some examples

- The prisioners’ dilemma

	C	D
C	1,1	-3,3
D	3,-3	(-1,-1)

Nash equilibria. Some examples

- The battle of sexes

	Mary	John
Mary	(5,2)	1,1
John	1,1	(2,5)

The ultimatum game

◆

		Acceptance	→	(a,c)	
				↑	
Proposer	a c	→	Responder	⇒	Payoff
				↓	
		Non-accept.	→	(0,0)	

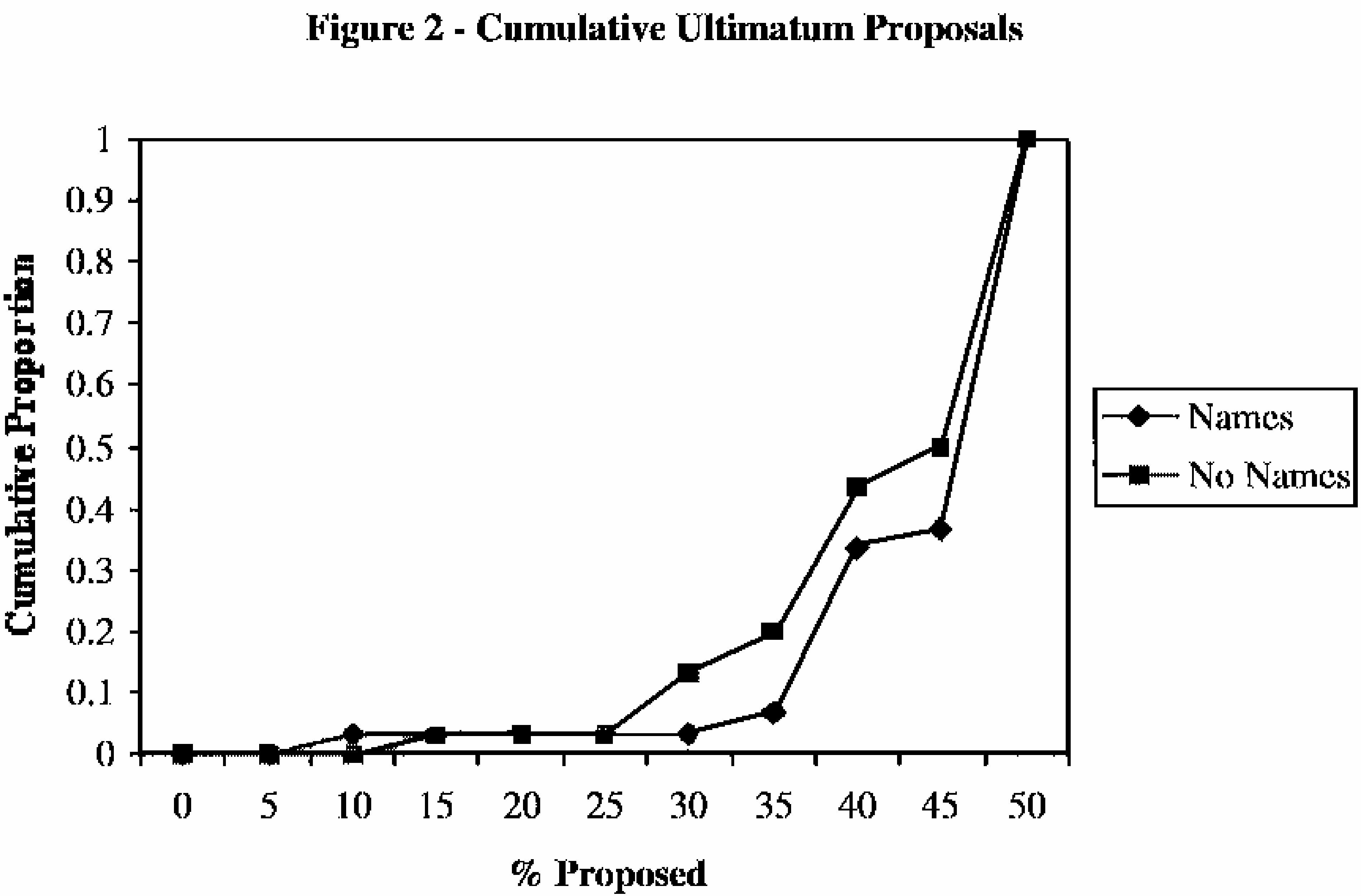
The ultimatum game

- a+c=2b , a>>c, (Example: a=99, c=1, b=50)

	R0	R1
P0	(a,c)	0,0
P1	b,b	0,0

Nash equilibrium and experimental games

- University students



Nash equilibrium and experimental games

- Small scale societies

Table 1. Ethnographic Summary of Societies

Group	Language Family	Environment	Economic Base	Residence	Complexity	Researcher	PC	MI
Machiguenga	Arawakan	Tropical Forest	Horticulture	Bilocal semi nomadic	Family	Henrich, Smith	1	4
Quichua	Quichua	Tropical Forest	Horticulture	Sedentary/ Semi-nomadic	Family	Patton	1	2
Achuar	Jivaroan	Tropical Forest	Horticulture	Sedentary/ Semi-nomadic	Family plus extended ties	Patton	5	2
Hadza	Khoisan/Isolate	Savanna-Woodlands	Foraging	Nomadic	Band	Marlowe	4	1
Ach	Tupi-Guarani	Semi-tropical Woodlands	Horticulture/ Foraging	Sedentary-Nomadic	Band	Hill, Gurven	6	4
Tsimane	Macro-Panoan Isolate	Tropical Forest	Horticulture	Semi-nomadic	Family	Gurven	1	3
Au	Torricelli/ Wapei	Mountainous Tropical Forest	Foraging/ Horticulture	Sedentary	Village	Tracer	3	5
Gnau	Torricelli/ Wapei	Mountainous Tropical Forest	Foraging/ Horticulture	Sedentary	Village	Tracer	3	5
Mapuche	Isolate	Temperate Plains	Small scale farming	Sedentary	Family plus extended ties	Henrich	2	6
Torguuds	Mongolian	High latitude desert Seasonally-flooded grassland	Pastoralism	Transhumance	Clan	Gil-White	2	8
Kazakhs	Turkic	High-latitude Desert Seasonally-flooded grassland	Pastoralism	Transhumance	Clan	Gil-White	2	8
Sangu	Bantu	Savanna-Woodlands Seasonally-flooded grassland	Agro-Pastoralists	Sedentary or Nomadic	Clan-Chiefdom	McElreath	5	8
Orma	Cushitic	Savanna-Woodlands	Pastoralism	Sedentary or Nomadic	Multi-Clan Chiefdom	Ensminger	2	9
Lamalera	Malayo-Polynesian	Island Tropical coast	Foraging-Trade	Sedentary	Village	Alvard	7	7
Shona	Niger-Congo	Savanna-Woodlands	farming	Sedentary	Village	Barr	5	8

Table 2 : Ultimatum Game Experiments

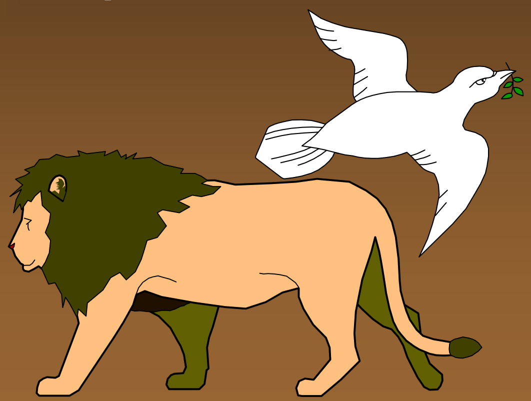
Group	Sample Size	Stake	Mean	Mode (% sample)[1]	Rejections	Low rejections [2]
Lamalera[3]	19	10	0.57	0.50 (63%)	4/20 (sham)[4]	3/8 (sham)
Ach	51	1	0.48	0.40 (22%)	0/51	0/2
Shona (Resettled)	86	1	0.45	0.50 (69%)	6/86	4/7
Shona (all)	117	1	0.44	0.50 (65%)	9/118	6/13
Orma	56	1	0.44	0.50 (54%)	2/56	0/0
Au	30	1.4	0.43	0.3 (33%)	8/30	1/1
Achuar	14	1	0.43	0.50 (36%)	2/15[5]	1/3
Sangu (herders)	20	1	0.42	0.50 (40%)	1/20	1/1
Sangu (farmers)	20	1	0.41	0.50 (35%)	5/20	1/1
Sangu	40	1	.41	0.50 (38%)	6/40	2/2
Shona (Unresettled)	31	1	0.41	0.50 (55%)	3/31	2/6
Hadza (big camp)	26	3	0.40	0.50 (35%)	5/26	4/5
Gnau	25	1.4	0.38	0.4 (32%)	10/25	3/6
Tsimane	70	1.2	0.37	0.5/0.3 (44%)	0/70	0/5
Kazakh	10	8	0.36	0.38 (50%)	0/10	0/1
Torguud	10	8	0.35	0.25 (30%)	1/10	0/0
Mapuche	31	1	0.34	0.50/0.33 (42%)	2/31	2/12
Hadza (all camps)	55	3	0.33	0.20/0.50 (47%)	13/55	9/21
Hadza (small camp)	29	3	0.27	0.20 (38%)	8/29	5/16
Quichua	15	1	0.25	0.25 (47%)	0/14[6]	0/3
Machiguenga	21	2.3	0.26	0.15/0.25 (72%)	1	1/10

Nash equilibrium and experimental games

- Homo Oeconomicus rejected in all cases
- The player's behavior is strongly correlated with existing social norms in their societies and market structure
- Human decision problems involve a mixture of self-interest and a background of (internalized) social norms
- Exits Homo Oeconomicus
- Enters Homo Reciprocans (Samuel Bowles, Herbert Gintis)
- Strong reciprocity

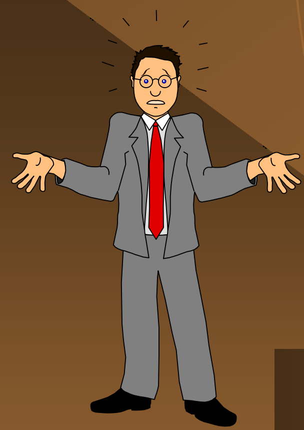
Homo reciprocans

- Homo reciprocans comes to new social situations with a propensity to cooperate and share, responds to cooperative behavior by maintaining or increasing the level of cooperation and responds to selfish free-riding behavior on the part of others by retaliating, even at a cost to himself and even when he could not expect future personal gains
- Strong reciprocity is a form of altruism in that it benefits others at the expense of the individual that exhibits this trait.



Homo reciprocans

- Monitoring and punishing selfish agents or norm violators is a costly (and dangerous) activity without immediate direct benefit to the agent that performs it
- It seems that the strong reciprocity trait could not invade a population of self-interested agents, nor be maintained in a stable population equilibrium
- Not evolutionary stable ?



Homo reciprocans. The Bowles-Gintis model

- Small hunter-gatherer bands of the late Pleistocene
- Population of size N with two species of agents:
- Reciprocators (R-agents)
- Self-interested (S-agents)
- Public goods activity: each agent can produce a maximum amount of goods q at cost b
- The benefit that an S-agent takes from shirking is the cost of effort $b(\sigma)$, σ being the fraction of shirking time
- $b(0)=b$ $b(1)=0$ $b'(\sigma)<0$ $b''(\sigma)>0$ $q(1-\sigma)>b(\sigma)$
- At every level of effort, working helps the group more than it hurts the worker

Homo reciprocans. The Bowles-Gintis model

- R-agents never shirk and punish free-riders at cost $c\sigma$, the cost being shared by all R-agents
- f = fraction of R-agents
- For an S-agent the estimated cost of being punished is $s\sigma$. He chooses σ^* to minimize the function

$$B(\sigma) = b(\sigma) + s\, f\, \sigma + q(1-\sigma)/N$$

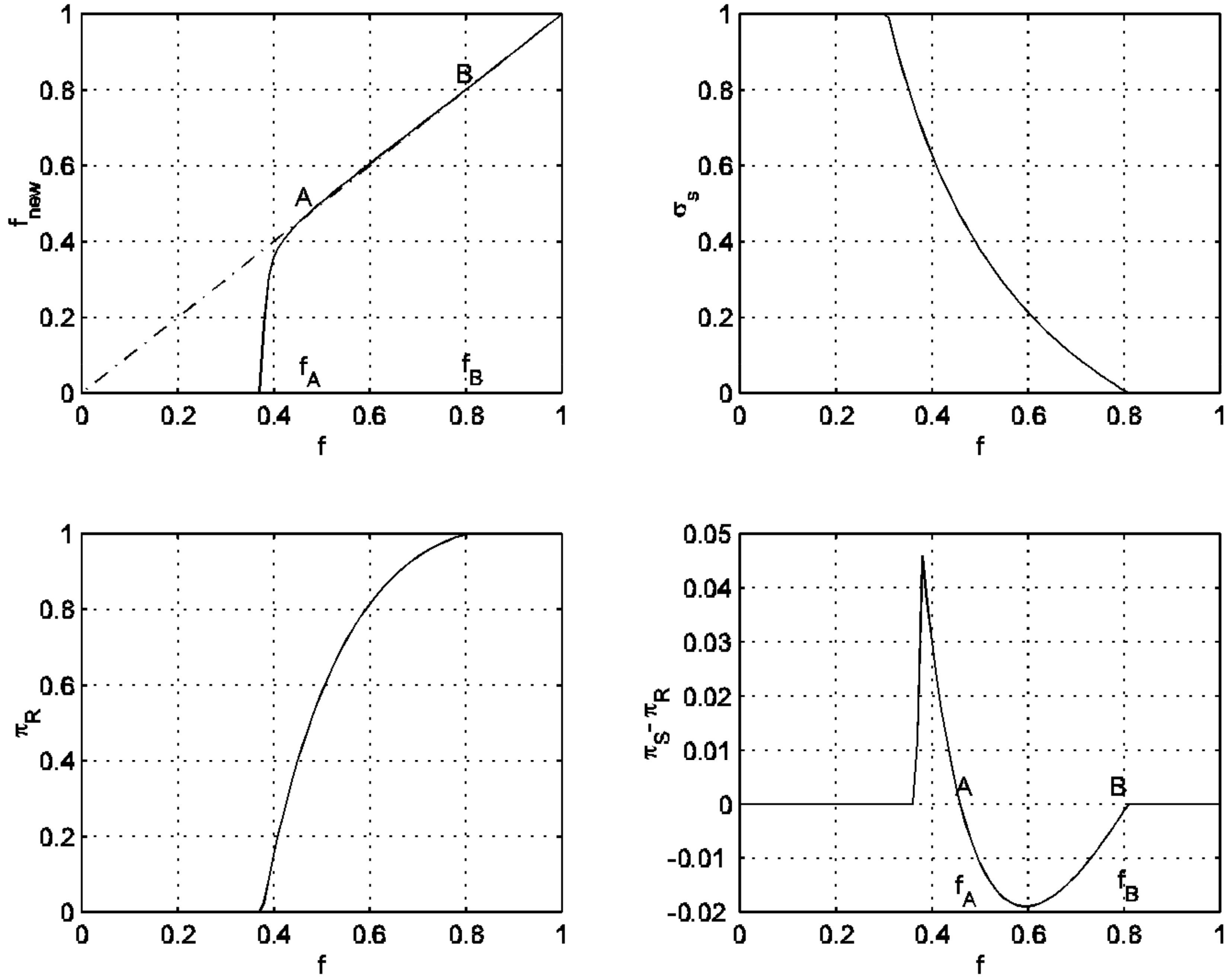
- Fitness of each species :

$$\pi_S = \max(\, q(1-(1-f)\,\sigma^*) - b(\sigma^*) - \gamma\, f\, \sigma^*\ ,\ 0)$$

$$\pi_R = \max(\, q(1-(1-f)\,\sigma^*) - b - c(1-f)N\sigma/(Nf)\ ,\ 0)$$

- Replicator dynamics

$$f_{new} = f\,\frac{\pi_R(f)}{(1-f)\pi_S + f\pi_R(f)}$$



q=2, b=1, s=2, c=0.1, γ=3.5, N=1000

Fig.1

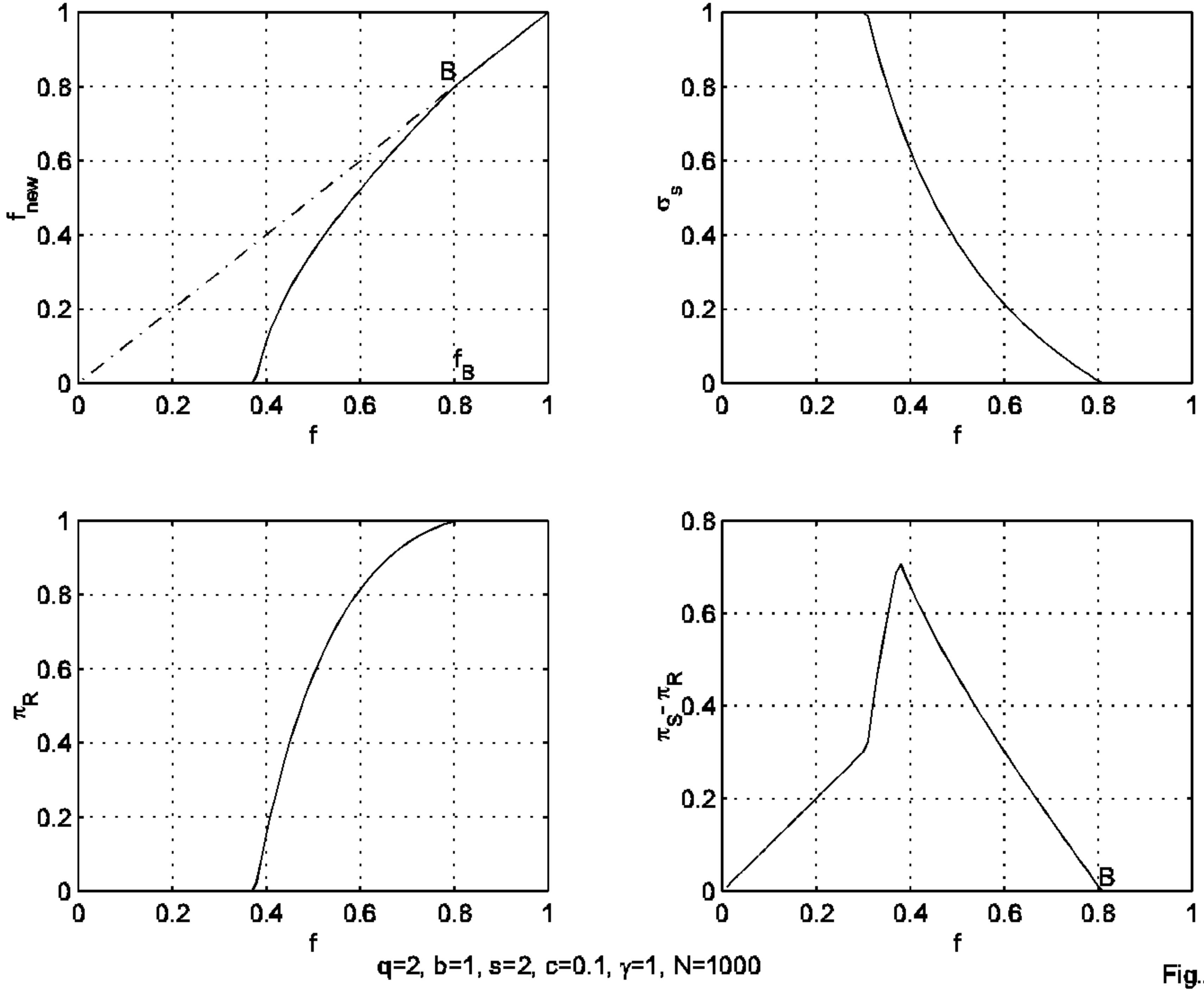


Fig.2

Homo reciprocans. The Bowles-Gintis model

- If γ is large enough, the map has an unstable fixed point (A) and a left-stable one (B)
- Between B and f = 1 there is a continuum of marginally stable fixed points
- For smaller γ the region between A and B disappears and only the marginally stable fixed points remain
- The asymptotic behavior corresponds either to f = 0 ($\sigma^*=1$) or to f between 0 and 1 but $\sigma^*=0$
- When $f \neq 0$, reciprocators and shirkers remain in the population but shirkers choose not to shirk
- For initial f smaller than f_A the fraction of reciprocators falls very rapidly to zero

Homo reciprocans. The Bowles-Gintis model

- *Intragroup dynamics* :
  either reciprocators are eliminated from the population or they remain in equilibrium with a large number of shirkers (which do not shirk for fear of being punished)
- Intragroup dynamics cannot explain how strong reciprocity might have become a dominant trait.
- *Intergroup dynamics* :
  Only groups that contain at the start $f>f_A$ will have in the end a nonzero fitness. All others suffer a "tragedy of the commons" with final zero fitness.
  Groups with reciprocators tend to dominate and impose an above average predominance of the reciprocator trait.

Network dependence of strong reciprocity

Network dependence of strong reciprocity

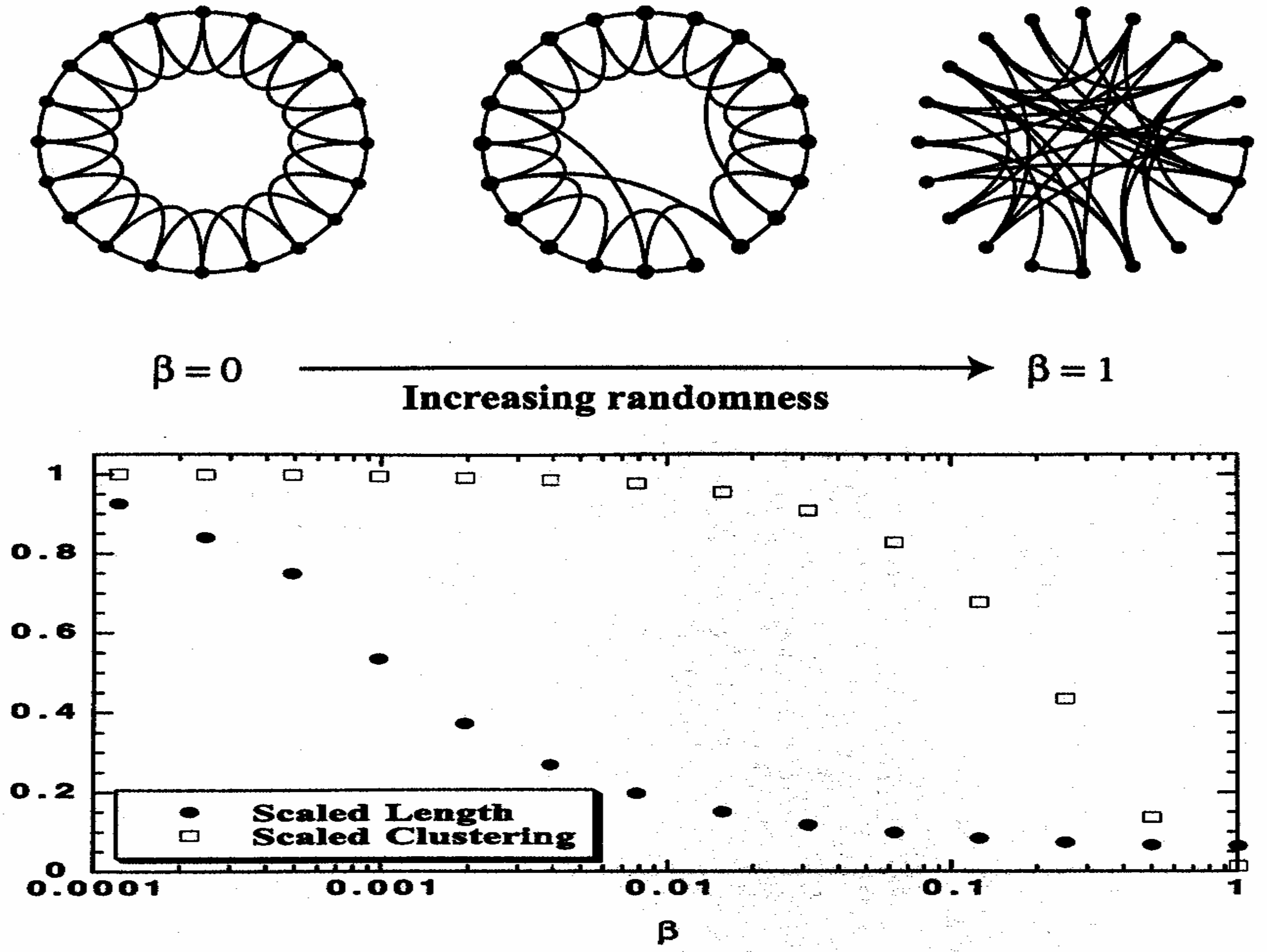
- What happens when, later on, the Pleistocene reciprocators and their fellow shirkers become imbedded into a larger society?
- Monitoring and punishment of shirkers by reciprocators necessarily looses its global collective nature.
- It becomes the business of the neighbors of the shirker
- Monitoring and (or) punishing free-riders requires force to insure the effectiveness of the punishment and to make the punisher safe from direct retaliation from the violator.
- Central authorities play a role in the control of serious offenses, but not so much on the day to day monitoring of public goods work

Network dependence of strong reciprocity

- Control by the neighbors plays a role on the evolution of the reciprocator trait.
- Genetically encoded trait → long time scale
- Culturally inherited trait → a much shorter time scale

Network dependence of strong reciprocity

- Punishing a norm-violator requires a minimal social power and consensus. Punishment only if at least two neighbors agree to do so.
- R-agents and (1-f) S-agents placed at random in a network where, on average, each agent is connected to k other agents, rewired with probability β
- Each reciprocator, on detecting an S-agent, looks for another reciprocator in his own neighborhood also connected to S-agent. If he finds one, he punishes by an amount proportional to the fraction of shirking.
- The amount of work an S-agent does is inversely proportional to the number of reciprocators in his neighborhood.



β = 0
β = 1
Increasing randomness
1
0.8
0.6
0.4
0.2
0
0.0001
0.001
0.01
0.1
1
β
Scaled Length
Scaled Clustering

Network dependence of strong reciprocity

- However lack of communication between neighboring reciprocators may make the probability of punishment much smaller.

Network dependence of strong reciprocity

- Wk( ) = work vector
- Pu( ) = punishment vector
- Cpu( ) = cost of punishment vector
- f = fraction of reciprocators
- q = maximum amount of goods produced by each agent
- b = cost of work
- c = cost to punish
- γ = cost to be punished

Network dependence of strong reciprocity

- Average fitness of R-agents and S-agents

$$\pi_R = \frac{q}{N}\sum_{all} Wk(i) - \frac{b}{fN}\sum_{R} Wk(i) - \frac{c}{fN}\sum_{R} Cpu(i)$$

$$\pi_S = \frac{q}{N}\sum_{all} Wk(i) - \frac{1}{(1-f)N}\left(b\sum_{S} Wk(i) + \gamma \sum_{S} Pu(i)\right)$$

Network dependence of strong reciprocity

- Replicator dynamics: Results of numerical simulation
  Region 1 : $f \rightarrow 0$ and $\pi = f\pi_R + (1-f)\pi_S \rightarrow 0$
  Region 2 : f and $\pi \neq 0$

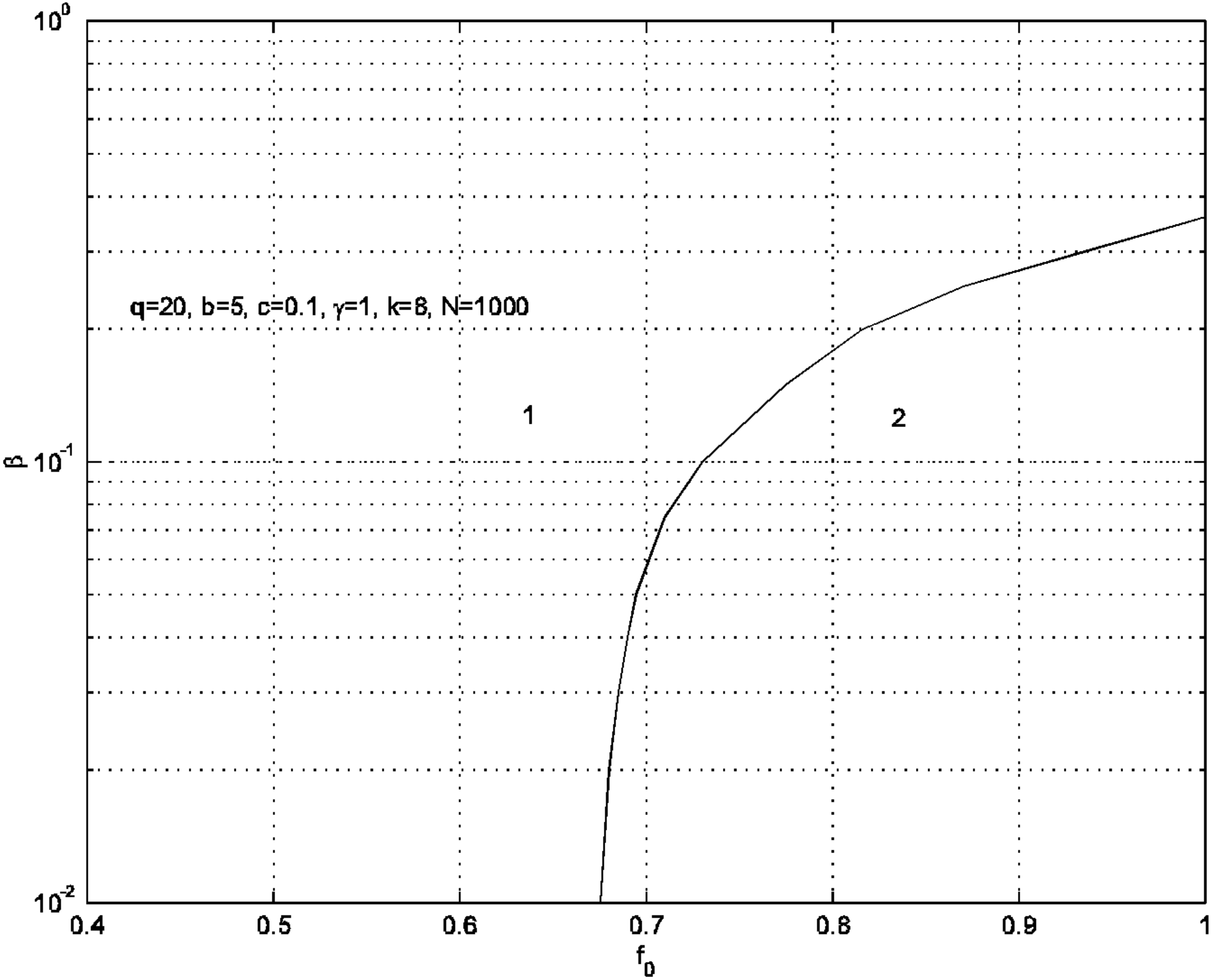


Fig.3

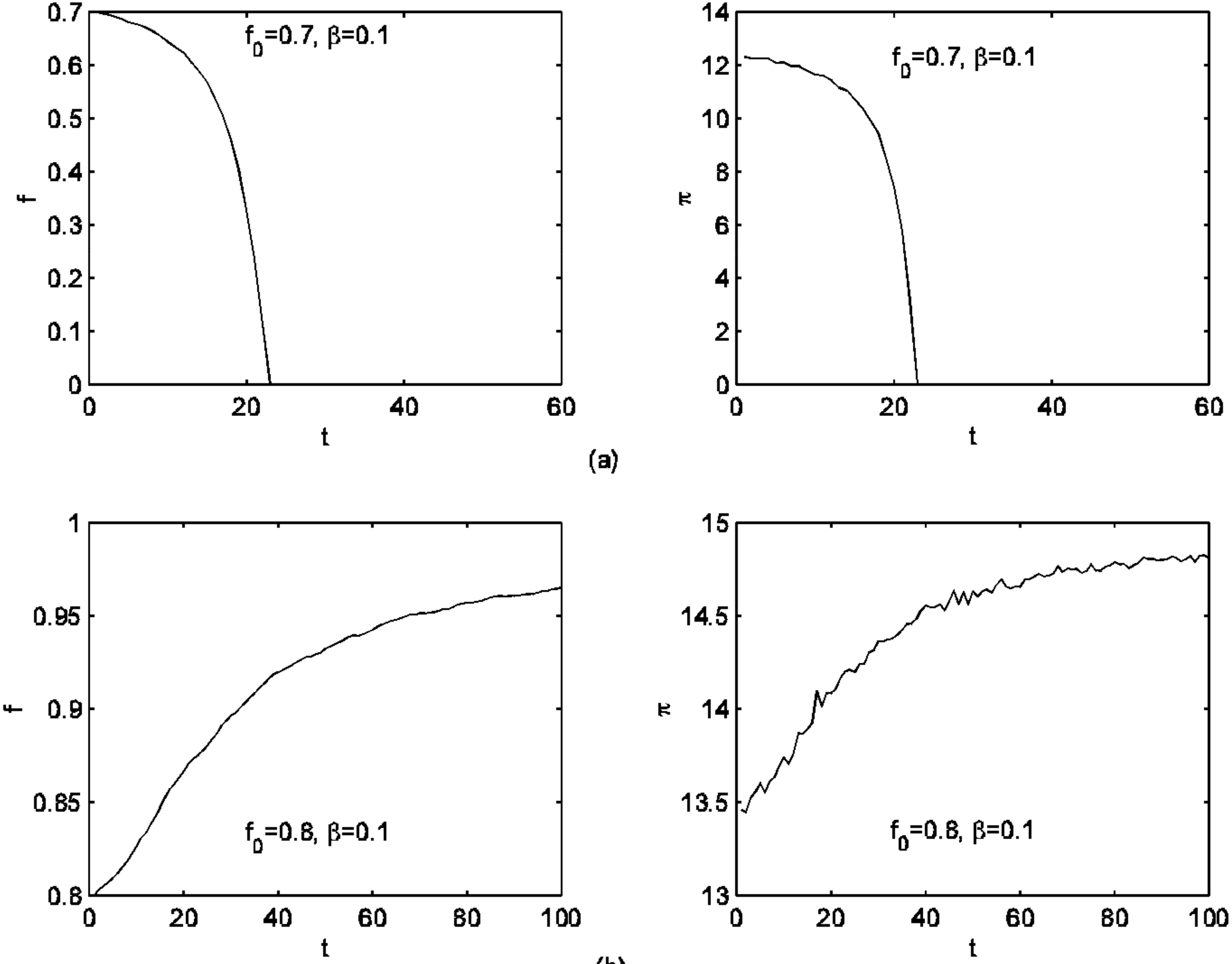


Fig.4

Network dependence of strong reciprocity

- Mean-field model

$$\pi_S = q(1-(1-f)\sigma^*(f)) - b(\sigma^*(f)) - f\gamma C_\beta(\Phi, fk)\sigma^*(f)$$

$$\pi_R = q(1-(1-f)\sigma^*(f)) - b - c(1-f)\tfrac{fk}{2} C_\beta(\Phi, fk)\sigma^*(f)$$

- with σ* chosen to minimize

$$B(\sigma) = b(\sigma) + sfC_\beta(\Phi, fk)\sigma - \tfrac{q}{N}(1-\sigma)$$

Similar conclusions

Conclusions

- 1 - In small groups with collective monitoring, the interplay of intra- an intergroup dynamics makes the emergence of the strong reciprocity trait a likely event.
- 2 - Self-interested (S-agents) are not completely invaded. If the social structure changes, they may be a source of instability and invade the population.
- 3 - In a large population, monitoring of the public goods behavior cannot be a fully collective activity and punishment of free-riders requires a certain amount of local consensus among reciprocators.
- 4 - The clustering nature of the society plays an important role in the maintenance and evolution of the reciprocator trait.

Conclusions

- Modern societies are "small worlds" in the sense of short path lengths but not necessarily in the sense of also maintaining a high degree of clustering.
- Therefore if the reciprocator trait has a high cultural component, it may very well happen that, eventually, we will see homo oeconomicus leaving the benches of economy classes for a life on the streets.

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The end