Network dependence of strong reciprocity

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- Emergence of strong reciprocity. The Bowles-Gintis model
- Network dependence of strong reciprocity
- Conclusions

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

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- 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

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

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- Fitness of each species :

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

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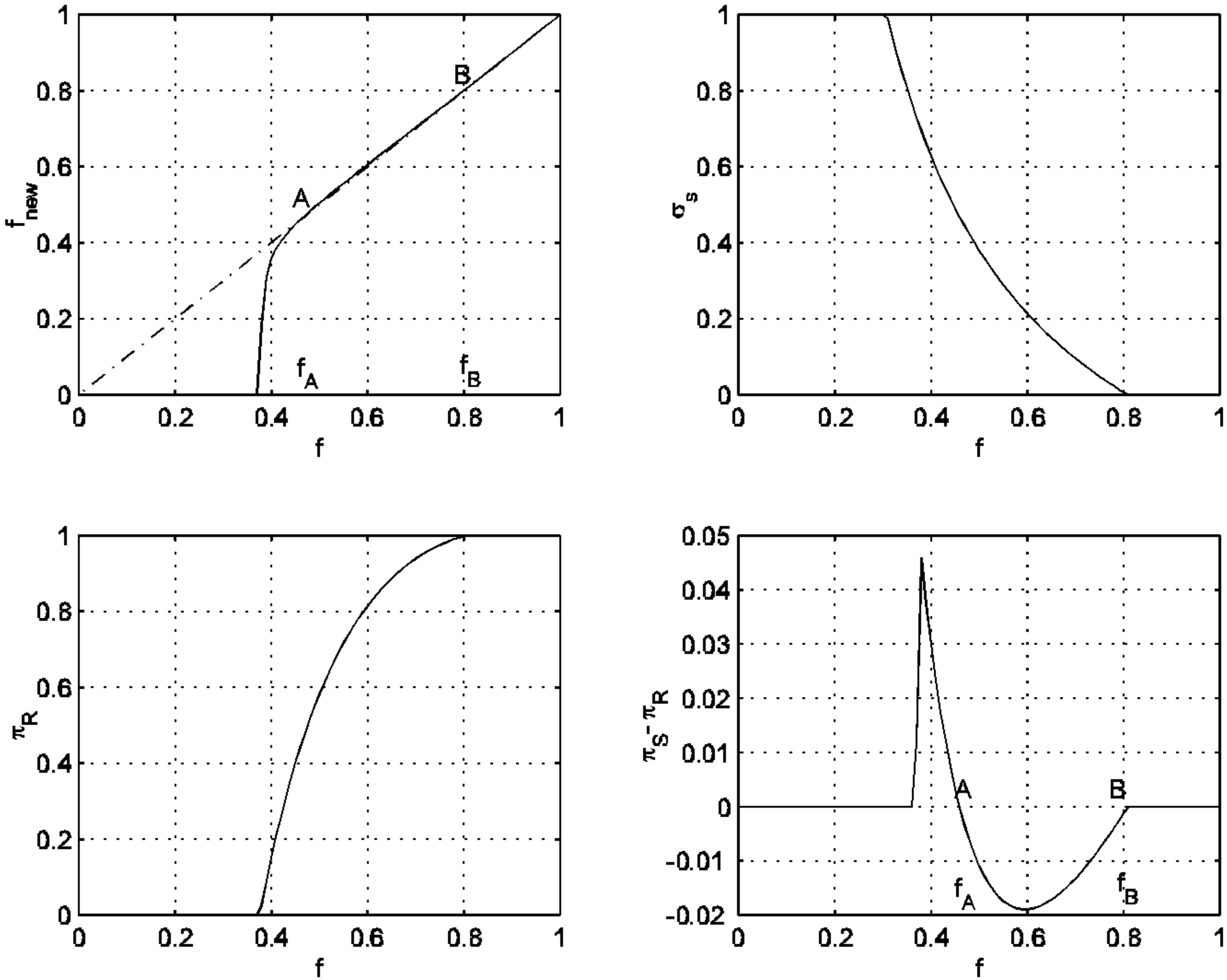
- Replicator dynamics

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



q=2, b=1, s=2, c=0.1, γ=3.5, N=1000

Fig.1

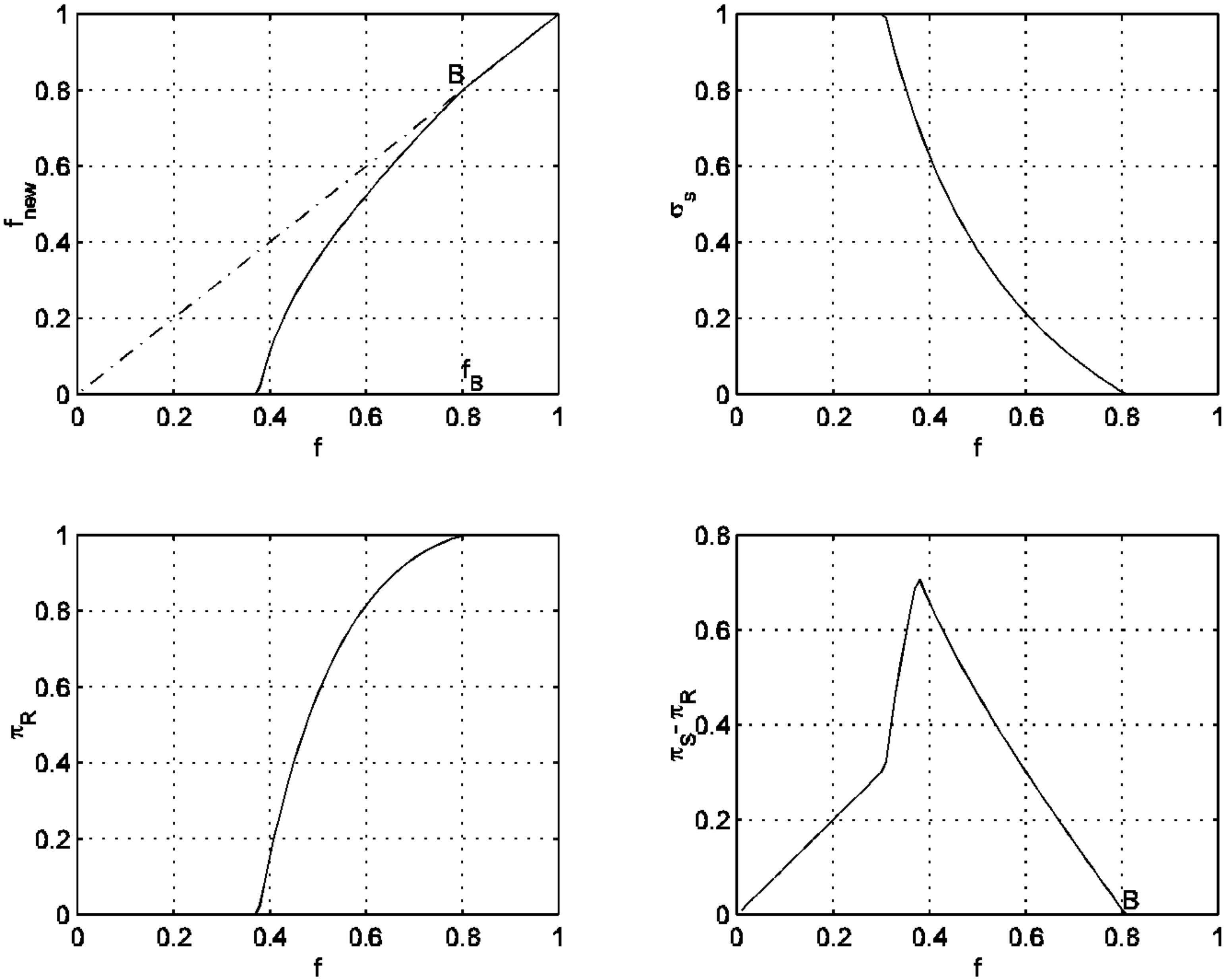


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Fig.2

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

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- 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

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  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.

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  Groups with reciprocators tend to dominate and impose an above average predominance of the reciprocator trait.

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- 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 $\longrightarrow$ long time scale
- Culturally inherited trait $\longrightarrow$ a much shorter time scale

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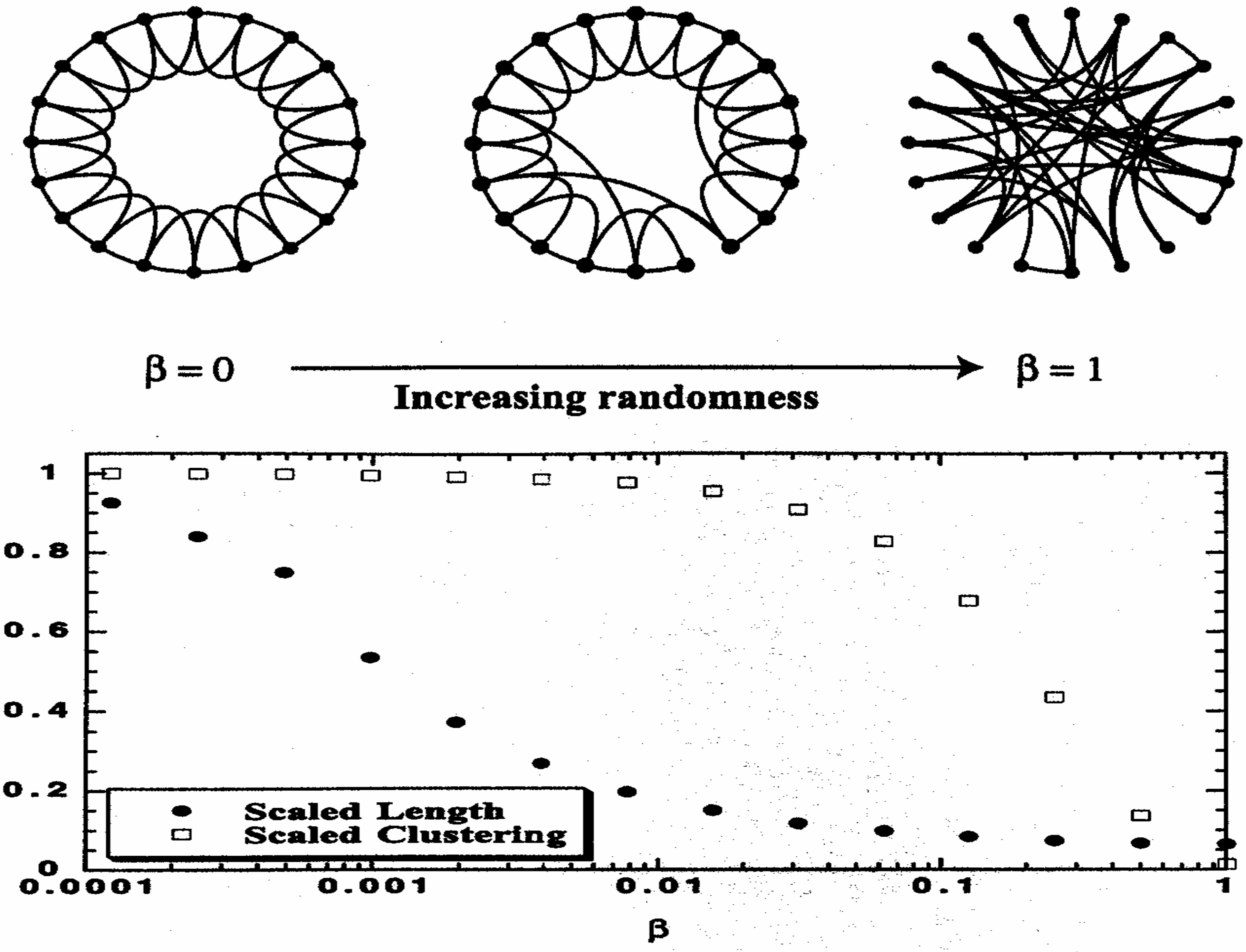
- Each reciprocator, on detecting an S-agent, looks for another reciprocator in his own neighborhood also connected to S-agent. If he finds one, he punishes by an amount proportional to the fraction of shirking.
- The amount of work an S-agent does is inversely proportional to the number of reciprocators in his neighborhood.


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

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- 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

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

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

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 $\pi \neq 0$

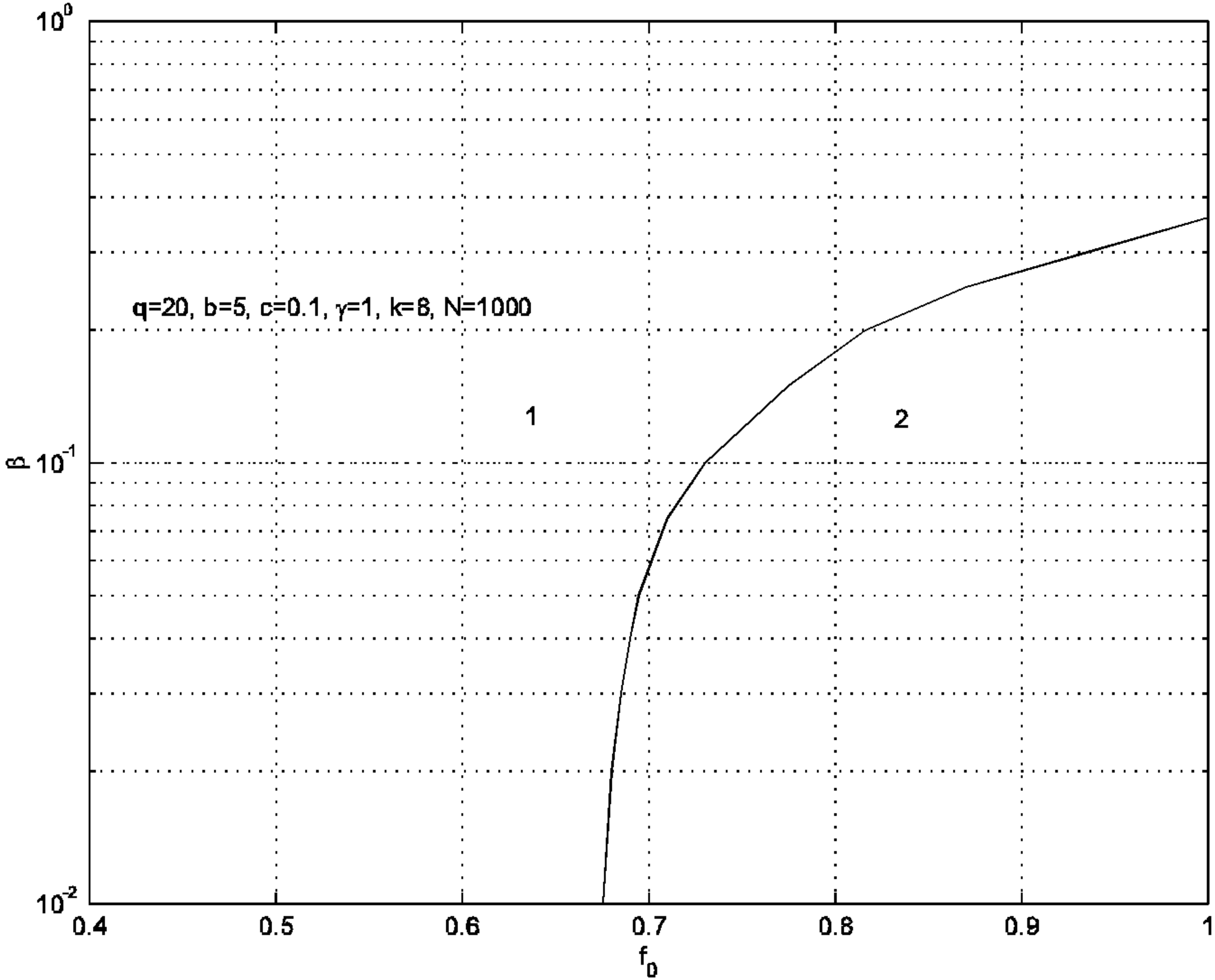

Fig.3

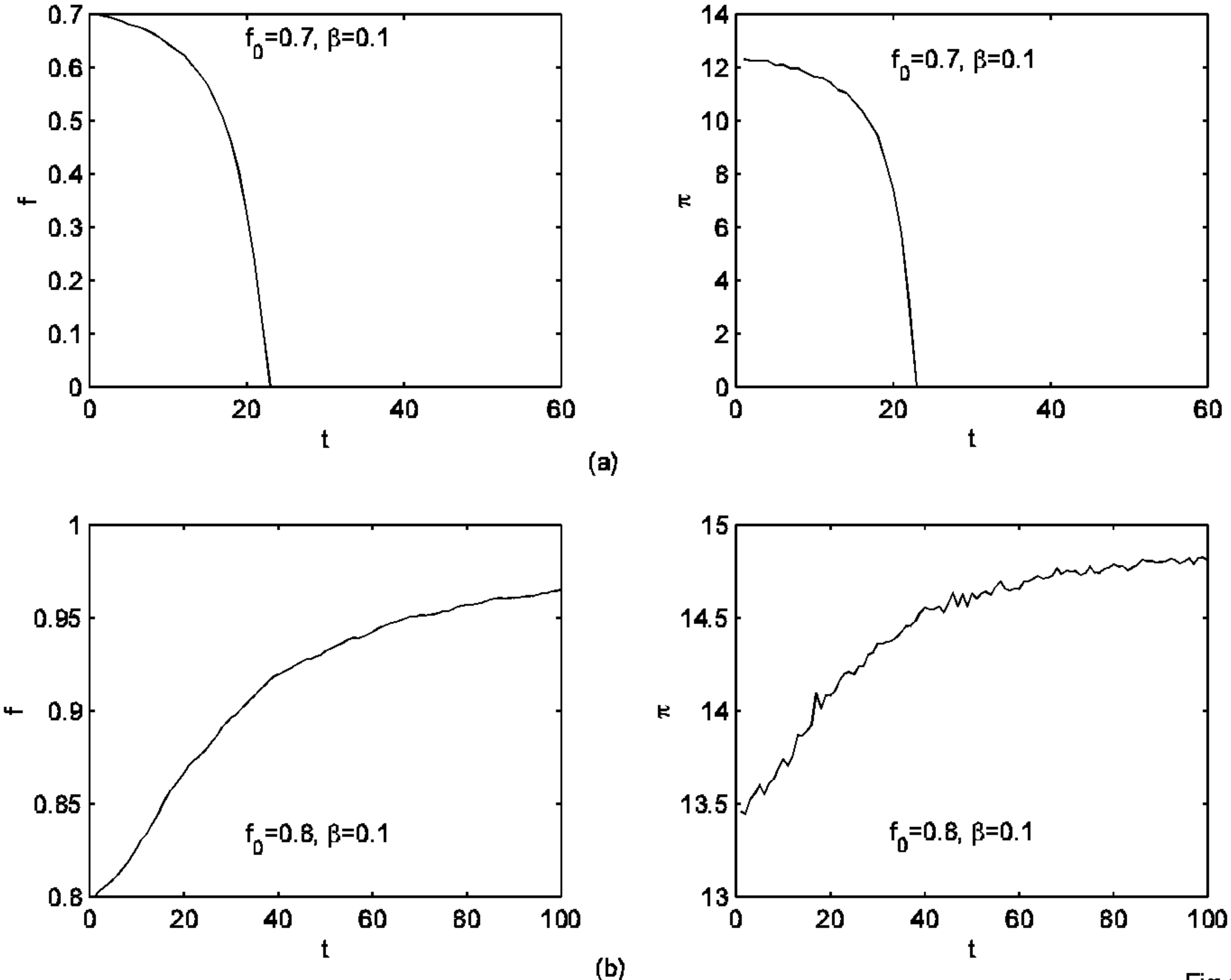

Fig.4

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

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- 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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