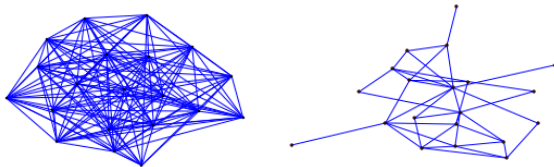


Inequality and the Evolution of Network Structure

Weikai Chen

University of Massachusetts, Amherst

Santa Fe, July 6, 2017



Motivations

Transition of Network Structures and Inequality

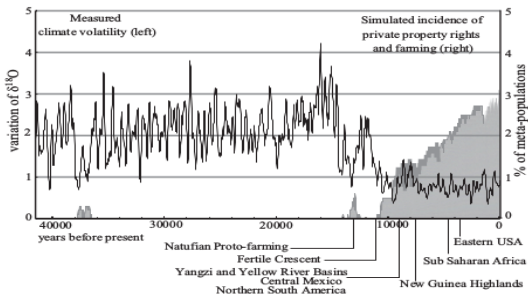


Figure: Climate variability and the emergence of farming and private property. Source: Bowles and Choi (2013)

Motivations

Coexistence of Dense and Star-like Networks

The dense Pokot are much more egalitarian than the star-like Himba (from ethnographic evidence)

	Pokot	Himba
Density	0.36	0.15
Inequality of degree	0.25	0.60
Betweenness	0.32	0.91
Inequality of betweenness	0.54	1.14

Figure: Density and inequality in two African herding networks.
Source Bollig (2006) as cited in Bowles (2009)

Motivations

Ecological Conditions → Network Structures → Inequality

● Transition of Network Structures and Inequality

Transition of Network Structures and Inequality

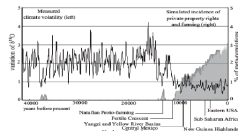


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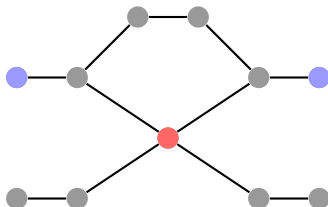
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Network Structures and Inequality

"Middleman" Model: Betweenness

The monopoly power in the communication between other nodes.

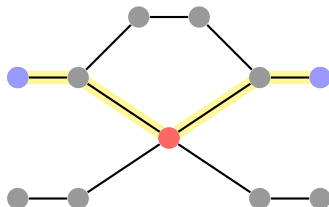


Goyal and Vega-Redondo, 2007; Hojman and Szeidl, 2008

Network Structures and Inequality

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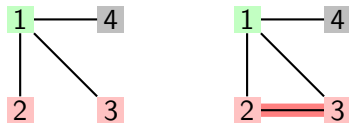


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Network Structures and Inequality

Cardinality of the Max Independent Set

How difficult to form coalitions.



Kets et.al, 2011

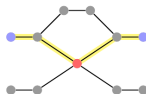
Summary

Ecological Conditions -> Network Structures -> Inequality

① Middle Man:

"Middleman" Model: Betweenness

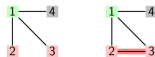
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② Coalition

Cardinality of the Max Independent Set

How difficult to form coalitions.



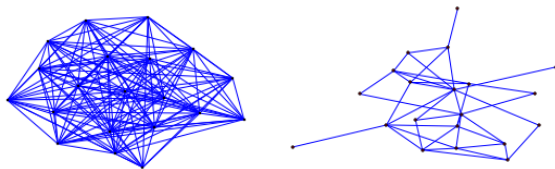
Density -> Equality

Star-like -> Inequality

Network Formation Model

The Network:

- Risk Sharing
- Team Production
- Trading
- Allies in political and other conflicts
- ...



Network Formation Model

Value Function:

- Links are valuable

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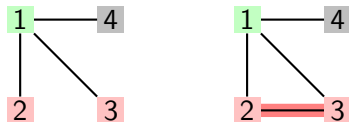
$$q_i(\delta) = \sum_{k=1}^{\infty} \delta^{k-1} n_i(k)$$

- Direct links cost c
- Value function: f can be concave, linear or convex.

$$v_i(G; \delta, c) = f(q_i(\delta)) - cd_i$$

Network Formation Model

Example



$$v_2(G_1) = f(1 + 2\delta) - c$$

$$v_2(G_2) = f(2 + \delta) - 2c$$

Network Formation Model

Formation Rule

- Two nodes are chosen

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 - form + form \rightarrow form
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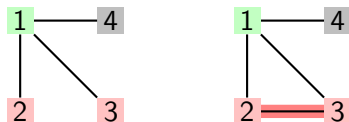
Network Formation Model

Formation Rule

- Two nodes are chosen
- Make decision:
 - if there is a link: do nothing or cut
 - if there is no connection: do nothing or form a link
- Outcome
 - form + form \rightarrow form
 - cut + ? \rightarrow cut
- Stable Network Structure: No individual or feasible coalition can benefit by deviating.

Network Formation Model

Example:

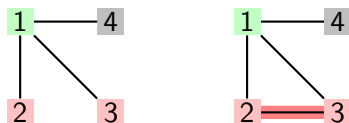


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Network Formation Model

Example:



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Best Reply: if $v_2(G_1) > v_2(G_2)$, agent 2 would like to cut the link

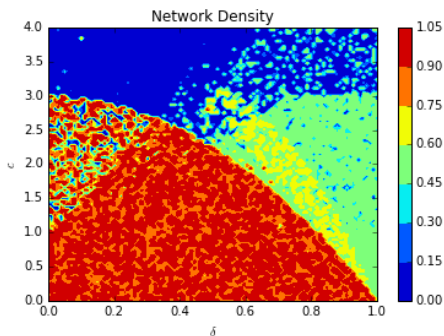
Stable Networks

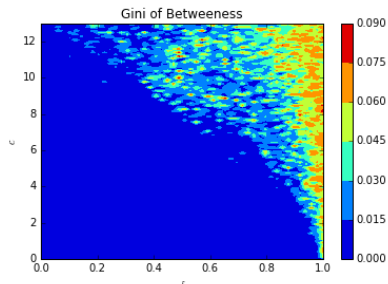
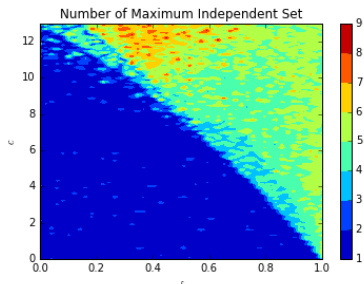
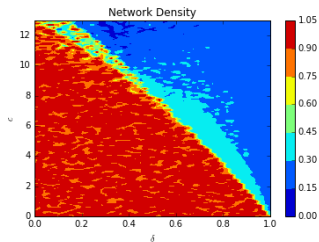
Show in the board when f is concave; linear, and convexity

Stable Networks

Show in the board when f is concave; linear, and convexity

Simulation Results $N=4$: The density of stable network depends on both the value of indirect links and costs.



Stable Networks: $N = 10$ 

The Transition: Hunter and Farmer

Transition of Network Structures and Inequality

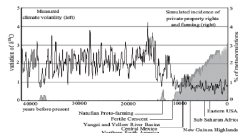


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The Transition: Hunter and Farmer

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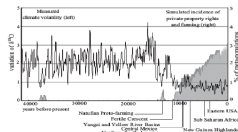


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- Hunter: c is low, perishable goods/face-to-face interaction δ is low
- Farmer: live far away c is high, δ is high

The Transition: Risk

Transition of Network Structures and Inequality

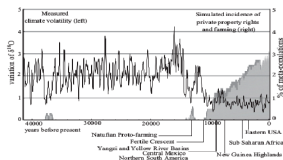


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Show in the Board.

- High Risk
- Low Risk

Summary

Ecological Conditions -> Network Structures -> Inequality

● Transition of Network Structures and Inequality

Transition of Network Structures and Inequality

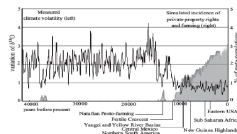


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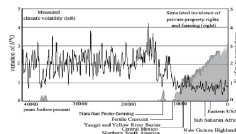


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Coexistence of Different Networks

Star is stochastically stable.

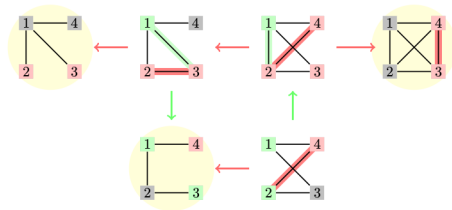
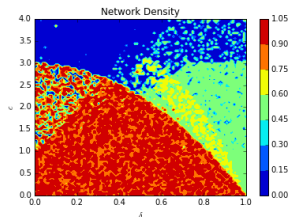


Figure 1: The Network of connected networks when $N = 4$ and $f = q^2$.

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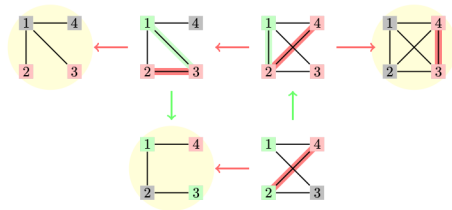
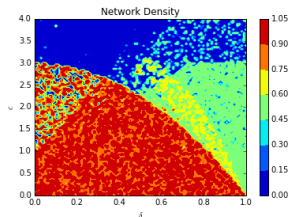


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Why coexists? - Inequality Comes in.

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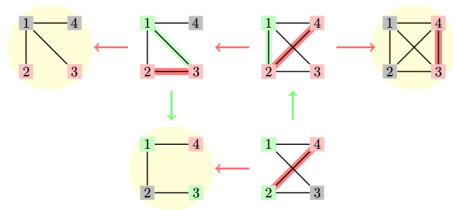
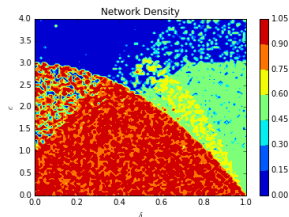


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Why coexists? - Inequality Comes in. Competition for resources between two society.

Thank you!