Financial crises and the evaporation of trust

Kartik Anand (ICTP, Trieste)
Prasanna Gai (ANU, Canberra) and Matteo Marsili (ICTP, Trieste)

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Credit is trust

Credit - Latin root *credere*, which means `*to trust*'.

Credit markets - Investors lend monies to each other with the promise of repayment.

> "A ***credit crunch*** is a breakdown in trust. That loss of trust has been the root cause of the devastating impact felt globally."

> "Events of the past two years can be re-told as a story of the progressive breakdown in trust." (Haldane, 2009)

A. G. Haldane (2009) *Credit is trust*. Bank of England
www.bankofengland.co.uk/publications/speeches/2009/speech409.pdf

Networks and financial crises

Modern financial systems ~ complex web of claims and obligations linking firms to financial institutions.

Intricacy of network ~ securitization and credit derivative markets.

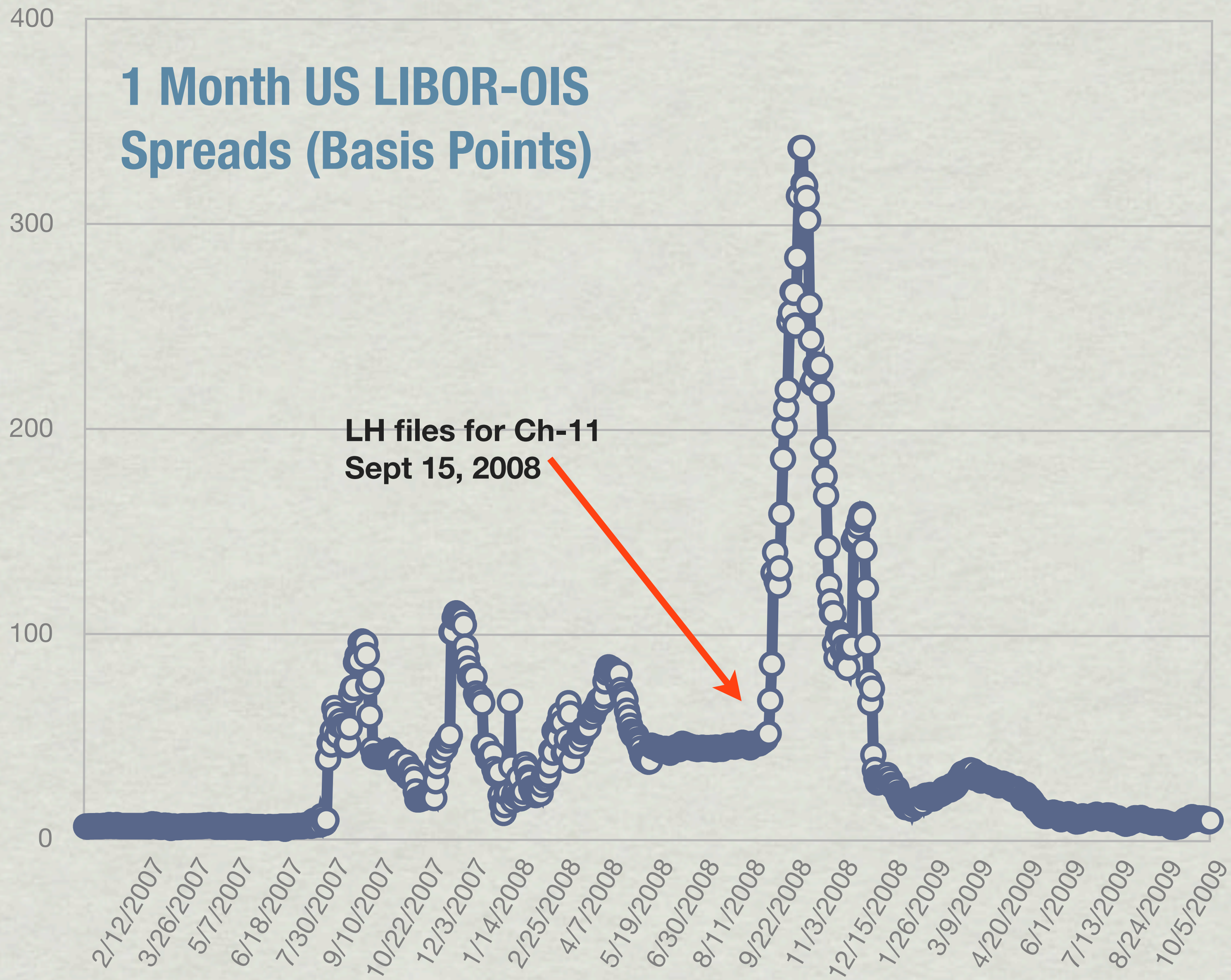
"Degradation of ecosystems, [...] and the disintegration of the financial system – each is essentially a different branch of the same network family tree." (Haldane, 2009)

"There is common ground in analyzing financial systems and ecosystems, especially to identify conditions that dispose a system to be knocked from seeming stability." (May et. al., 2008)

A. G. Haldane (2009) *Rethinking the financial network*. Bank of England www.bankofengland.co.uk/publications/speeches/2009/speech386.pdf

R. M. May *et. al.* (2008) Complex systems: ecology for bankers. Nature. **451**. 893-95

Interbank market freeze



Proximate cause
breakdown of trust.

Re-enforcing dynamics
“Credit - the disposition of one mans trust in another - is singularly varying [...] after a great calamity everyone is suspicious of everyone; as soon as the calamity is forgotten everybody confides in everybody.**”** (Bagehot 1873)

W. Bagehot (1973) *Lombard Street: A description of the money market*. London: Henry S. King & Co.

Outline

Modeling credit networks.

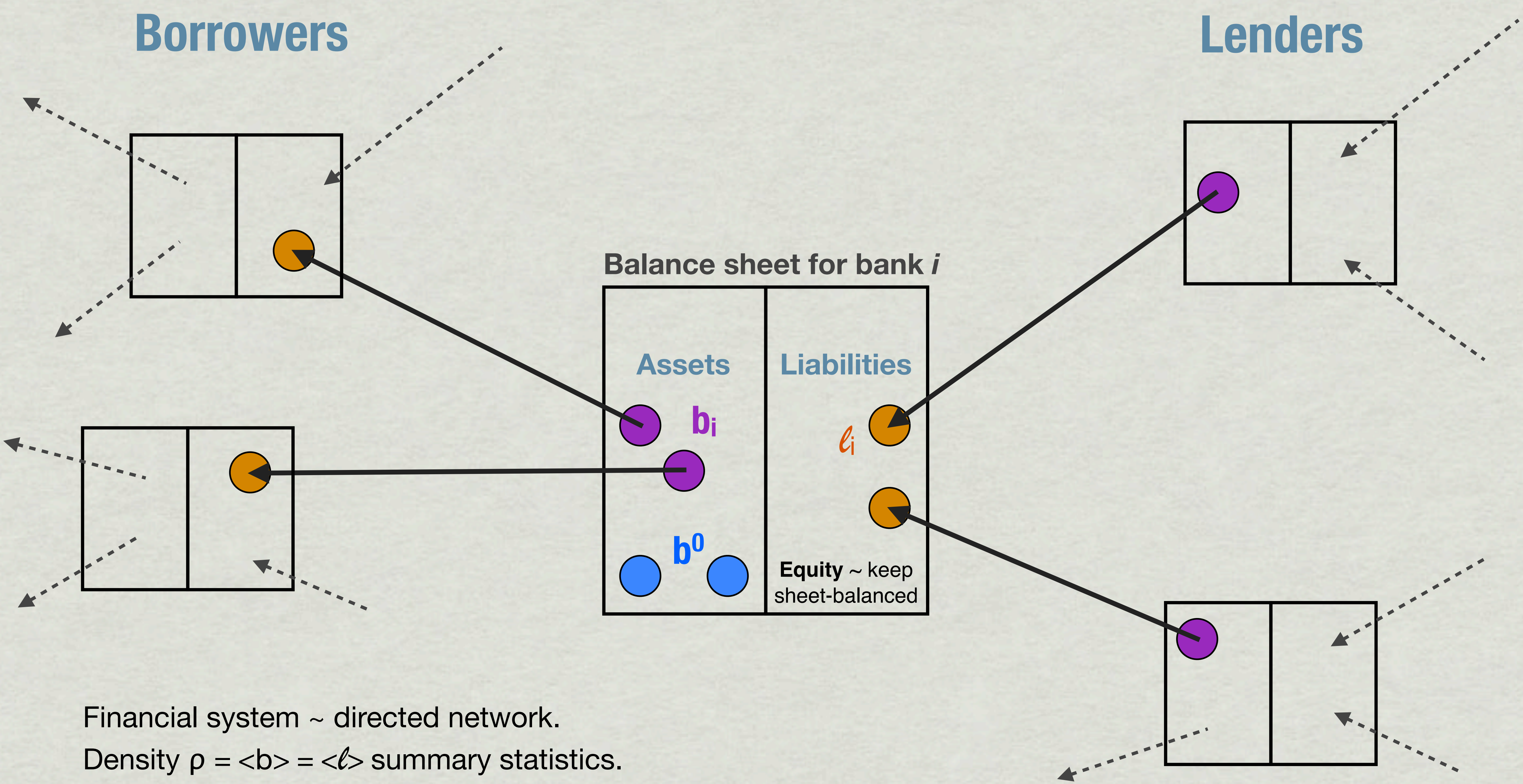
Strategic uncertainties and local coordination games.

Scaling up with network growth model.

Results - sharp transitions and hysteresis.

Summary.

Credit networks



Financial system ~ directed network.

Density $\rho = \langle b \rangle = \langle \ell \rangle$ summary statistics.

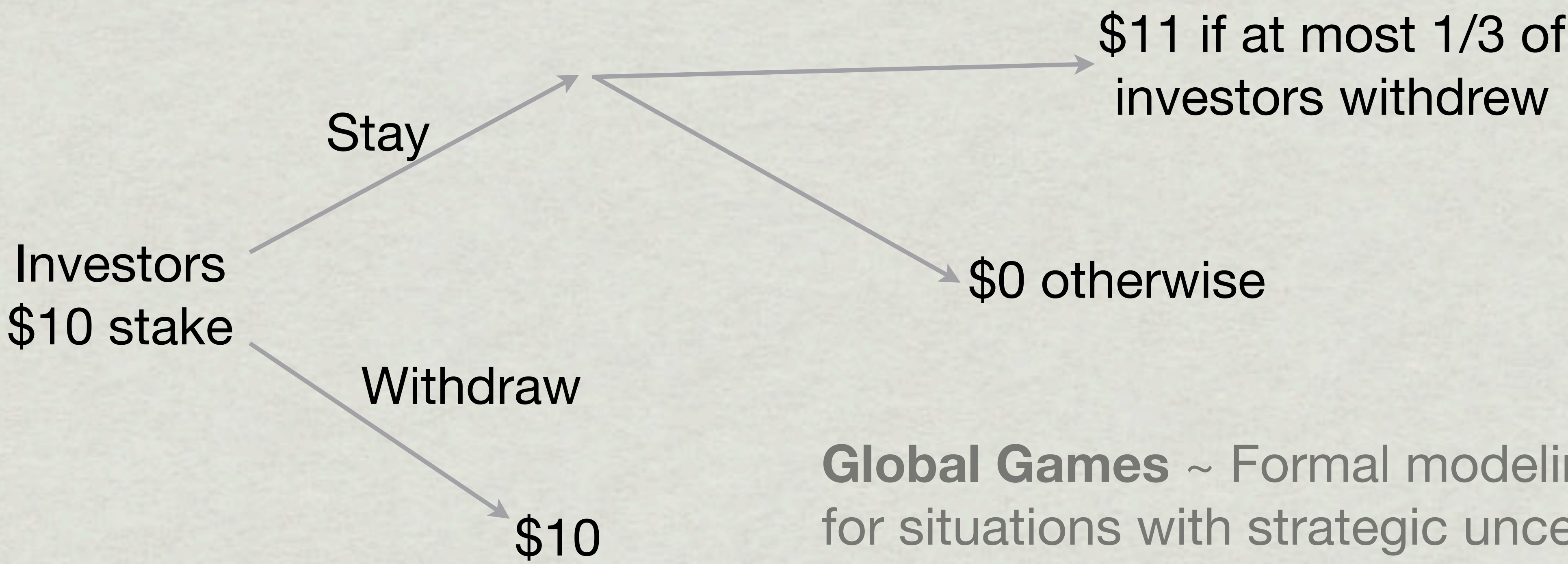
Question: What drives the decision to foreclose/rollover?

Strategic uncertainties

The uncertainty not on fundamental profitability of counter-party but on the actions of other stakeholders.

Examples Bank runs; Speculative attacks on currency peg

Larry Summer’s game



Global Games ~ Formal modeling approach for situations with strategic uncertainties (Morris and Shin 1998, 2000, 2002).

Agents receive ***private signals*** on state of fundamental - imperfect common knowledge.

Unique equilibrium.

S. Morris and H. S. Shin (1998) Unique equilibrium [...] currency attacks. *Amer. Econ. Rev.* **88**. 587-597
(2000) Global games: theory and applications. ssrn.com/abstract=284813
(2002) Measuring strategic uncertainty. http://www.princeton.edu/~hsshin/www/barcelona.pdf

Foreclosure game

Initial period

Banks *j*, *k*,... give short-term loans to bank *i* and expect returns in final period.

Interim period

Bank *i* reveals level of assets and liabilities on its' balance sheet.

Counter-parties decided to: ***Rollover*** or ***Foreclose*** loans.

Final period

Counter-parties who rolled over loans get good payoff if ***sufficient number*** **($> b_i + b_i^0$)** of banks also rolled over loans.

If too few **($< b_i + b_i^0$)** counter-parties rolled over ~ bad payoff.

Foreclosure game

Decision to roll over depends on how difficult each bank believes it will be to coordinate.

Cost of mis-coordination (**private signal**) ~ c_j

Potential cost of failing to coordinate.
Higher c_j ~ Bank *j* worried; more difficult to coordinate.

	$\ell_i' \geq b_i + b_i^0$	$\ell_i' < b_i + b_i^0$
foreclose	0	0
roll over	$1 - c_j$	$-c_j$

.

where ℓ_i' is number of banks who roll-over loans.

Foreclosure game

Switching strategy:
Rollover if $c_j < c^*$; else foreclose.

Suppose $c_j = c^*$ (indifferent between actions).

$$\mathrm{Prob}(\ell_i' \geq b_i + b_i^0 | c_j = c^\star) = c^\star \, .$$

Probability banks face costs smaller than $c_j = c^*$
~ Probability c_j is $(\ell_i' + 1)^{st}$. Hence, by symmetry:

$$\begin{cases} \text{rollover} & \text{if} \quad c_j \leq c^\star \\ \text{foreclose} & \text{if} \quad c_j > c^\star \end{cases} \quad \text{with } c^\star \equiv \frac{b_i + b_i^0 + 1}{\ell_i + 1} .$$

Scaling to network level

Assume homogenous $c_j = c_i = c$.

Three main ingredients:

Links added at *random* rate γ.

Links decay at rate λ.

At rate ν ~ banks *i* discloses its' balance sheet position to counter-parties.

Link addition (rate γ)

Unsecured loans made without knowledge of counter-parties' current positions.

Link (asset/liability) added between two agents.

Analogy ~ anonymous brokered trading in the interbank market.

Reflection of *a priori* trust.

Link decay (rate λ)

Loans mature and are amicably settled between counter-parties.

Link (asset/liability) removed between two agents and balance sheets are updated.

Disclosure (rate ν)

Poisson times t_ν ~ (ℓ_k, b_k) disclosed to lenders of *k*.

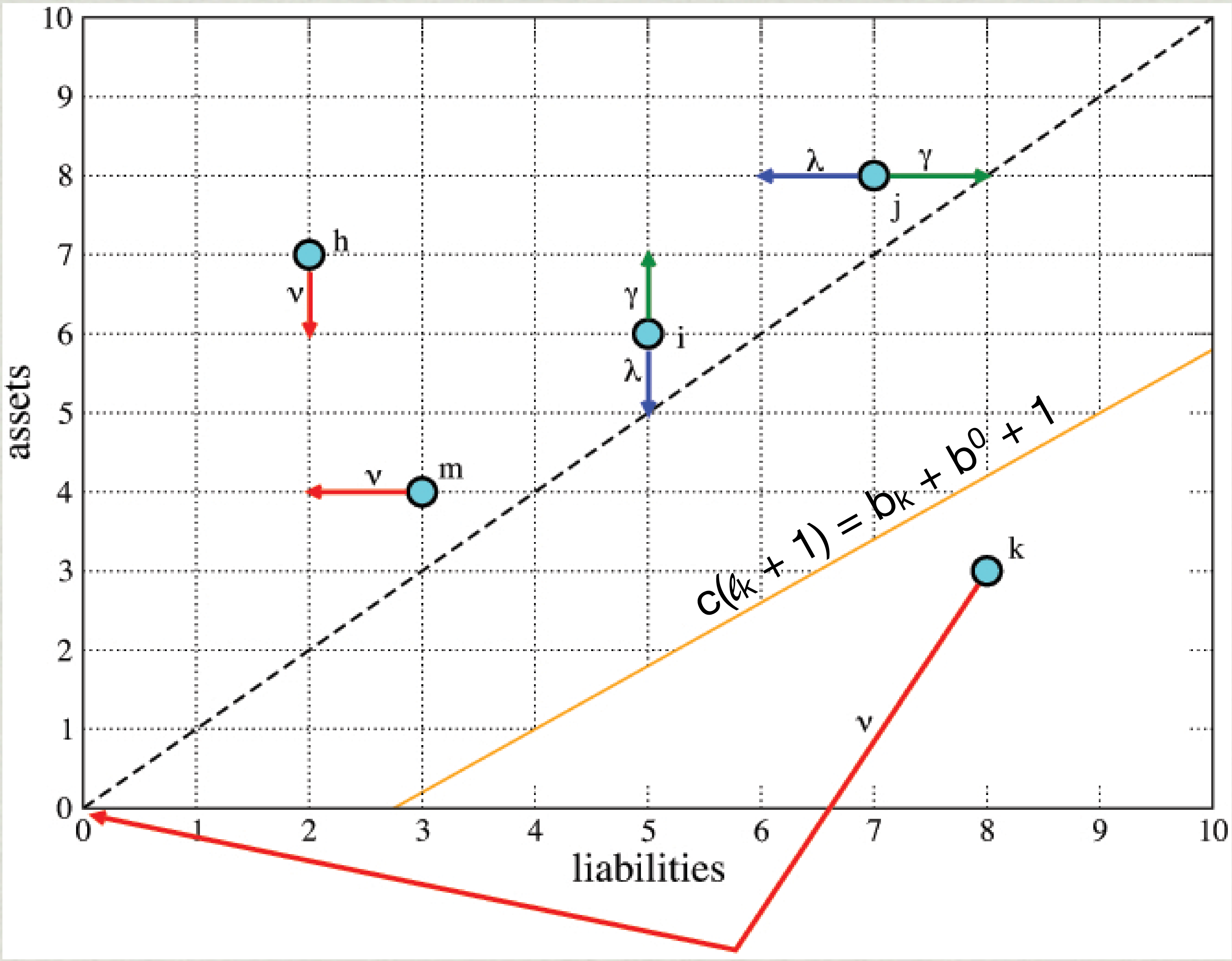
Lenders decide to either roll-over loan until maturity or foreclose.

Simple rule to follow ~ foreclose their loans if

$$c(\ell_k + 1) > b_k + b^0 + 1 \ .$$

Foreclosure ~ each lender looses a link (asset).
Bank *k* stripped of all links.

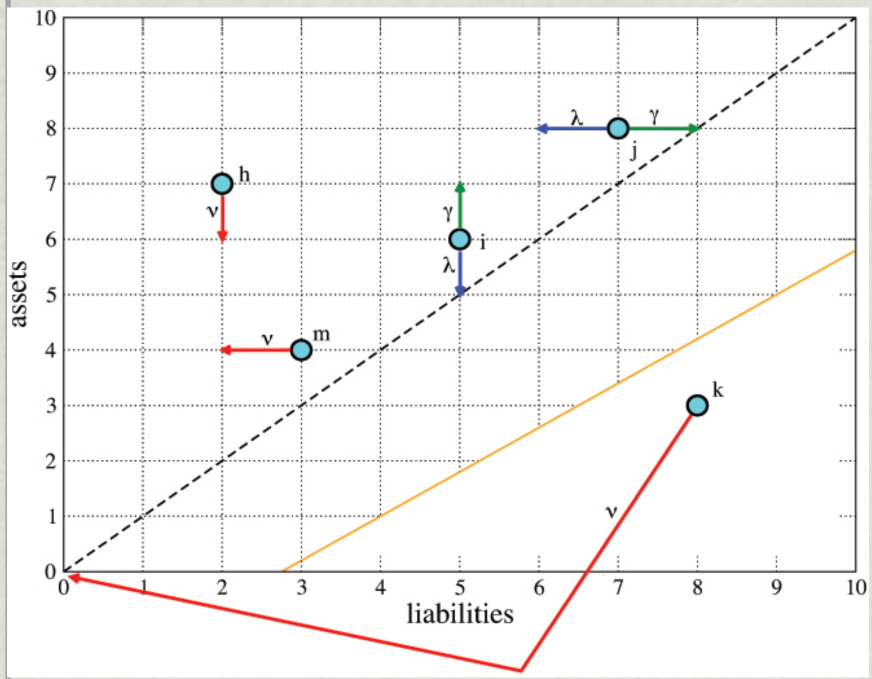
Scaling to network level



Master equation

$$
\begin{aligned}
\partial_t P(\ell,b) &= \mu\,\delta_{\ell,0}\,\delta_{b,0} + \gamma\,P(\ell-1,b) + \gamma\,P(\ell,b-1) + (\lambda+\mu_b)(\ell+1)P(\ell+1,b) \\
&+ (\lambda+\mu_l)(b+1)P(\ell,b+1) - \Big[\nu\,\Theta\Big(c(\ell+1)-1-b-b^0\Big) \\
&+ 2\gamma + (\lambda+\mu_b)\,\ell + (\lambda+\mu_\ell)\,b\Big]P(\ell,b)\,.
\end{aligned}
$$

μ, μ_b, μ_ℓ ~ Endogenous rate of link decay.

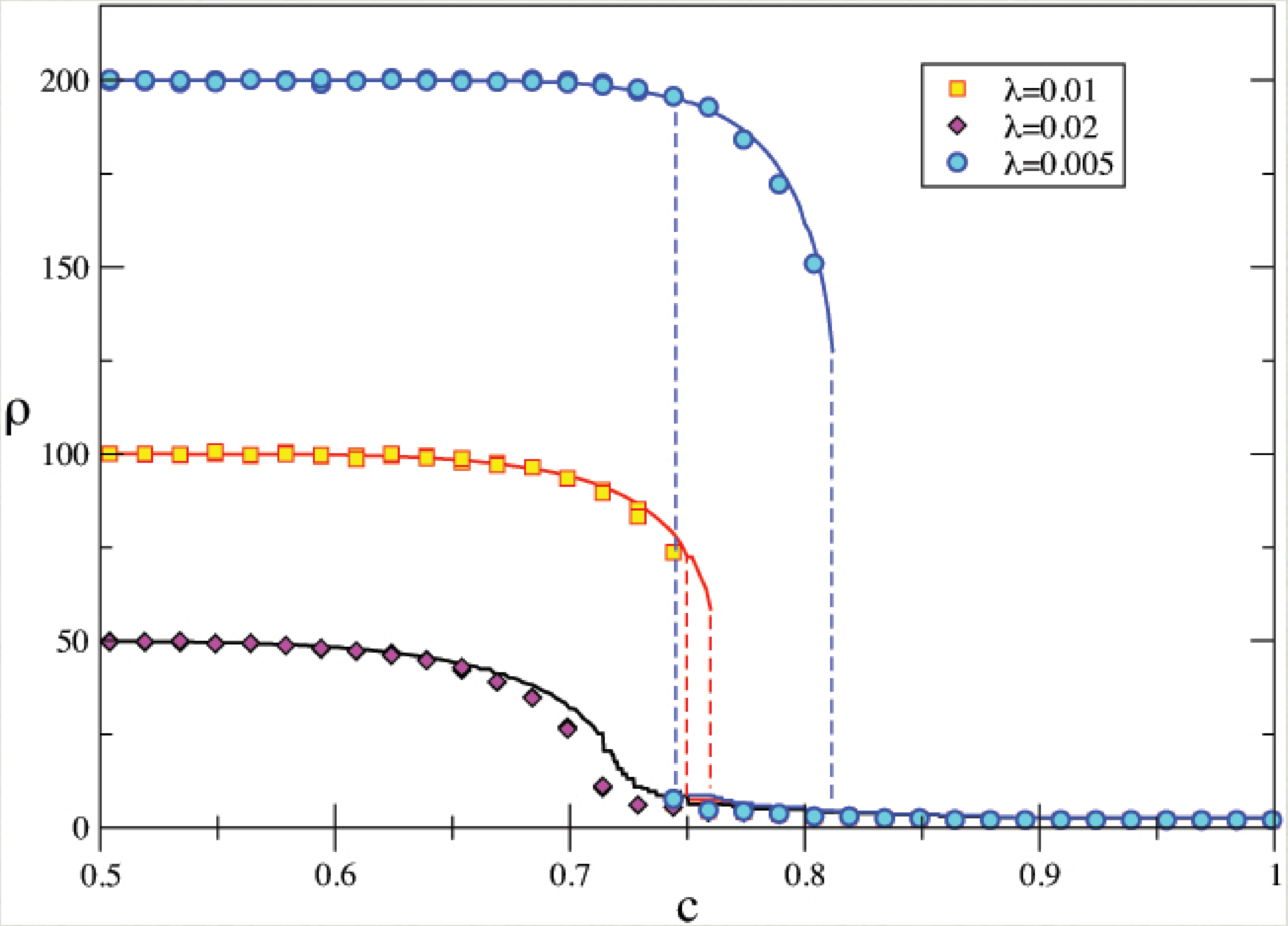


$$
\begin{aligned}
\mu &= \nu\sum_{\ell,b}\Theta\Big(c(\ell+1)-b-b^0\Big)P(\ell,b)\,, \\
\mu_\ell &= \frac{\nu}{\langle\ell\rangle}\sum_{\ell,b}\Theta\Big(c(\ell+1)-b-b^0\Big)\,\ell\,P(\ell,b)\,, \\
\mu_b &= \frac{\nu}{\langle b\rangle}\sum_{\ell,b}\Theta\Big(c(\ell+1)-b-b^0\Big)\,b\,P(\ell,b)\,.
\end{aligned}
$$

Results

EVAPORATION OF TRUST

ρ = CREDIT NETWORK DENSITY



circles ~ simulations

lines ~ numerical solution of master equation

Approximate solution

μ ~ Endogenous rate of link decay.

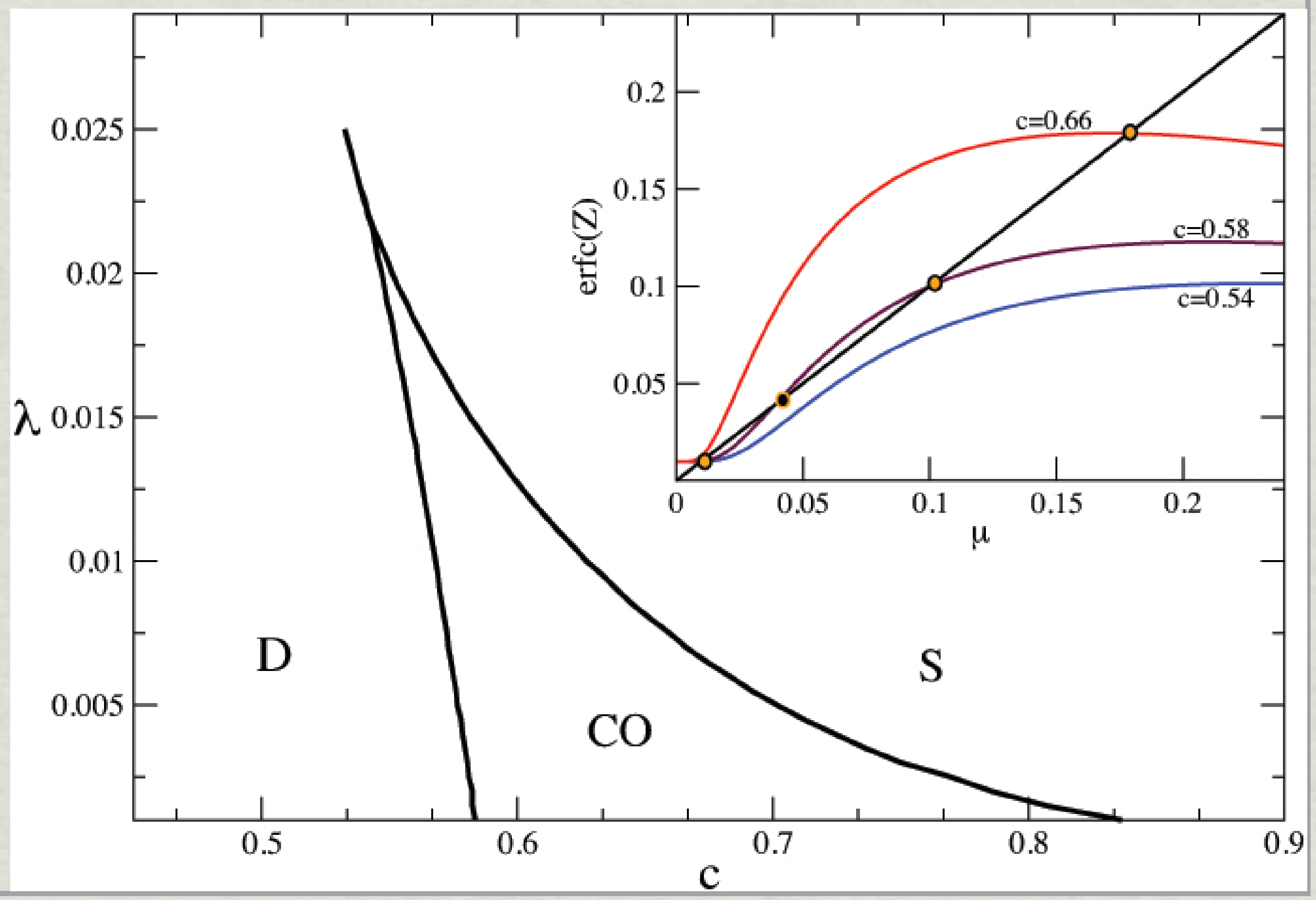
Considering twin stochastic processes ($\ell^{(t)}$, $b^{(t)}$)

$$\mu = \nu\,\mathrm{Prob}(b^{(t)} + b^0 + 1 - c \leq c\ell^{(t)})$$

$$\simeq \frac{\nu}{2}\mathrm{erfc}(Z)$$

$$Z = \frac{1 - c + b^0(\lambda + \mu)}{\sqrt{2(1+c^2)(\lambda+\mu)}}$$

erfc ~ complimentary error function



Policy considerations

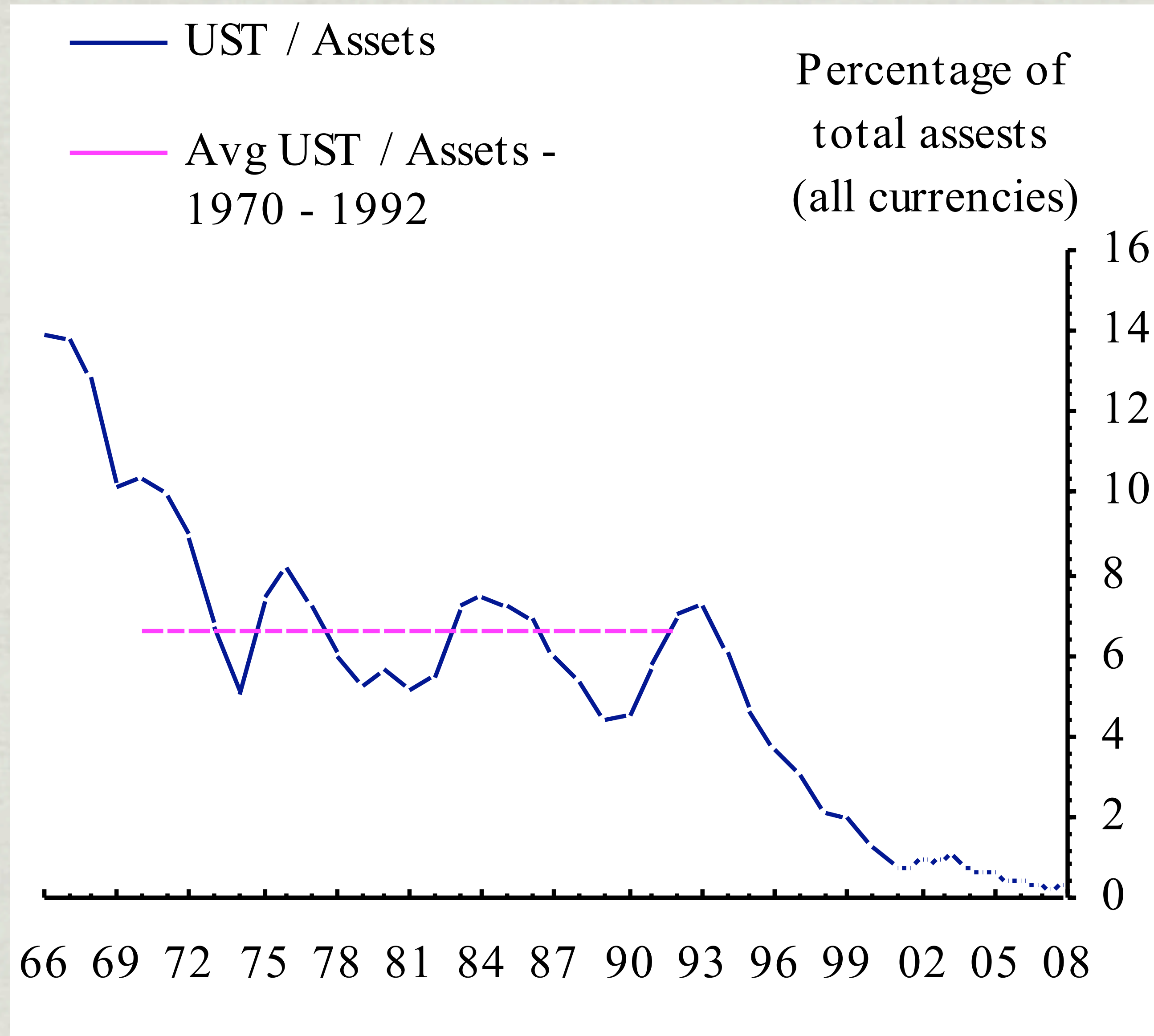
Regulation needs to address liquidity ratios of banks.

Higher liquidity ~ lower c ~ investors more trustworthy.

Similar to Greenspan-Guidotti rule (low debt-to-reserve ratio) for emerging market economies during 1997 Asian crisis.

$$b^0 = \beta + \alpha\ell \qquad c \sim c - \alpha \qquad b^0 \sim \beta - \alpha$$

Regulation targeted as *systemically important* (‘too big too fail’) banks to have higher liquidity ratios.



Summary

Model of credit freeze ~ taking global games intuition to network level.

Sharp transition ~ maturity mismatch (finance illiquid assets on balance sheet with short-term borrowing) ~ small λ/ν.

Hysteresis ~ trust regained after significant effort.

Regulation ~ address liquidity levels (e.g., Greenspan-Guidotti rule).

Use network based metrics to define systemically important financial institutions.