BES/LSE

ECO**-2 SYMPOSIUM

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Stability and Complexity in Financial Ecosystems

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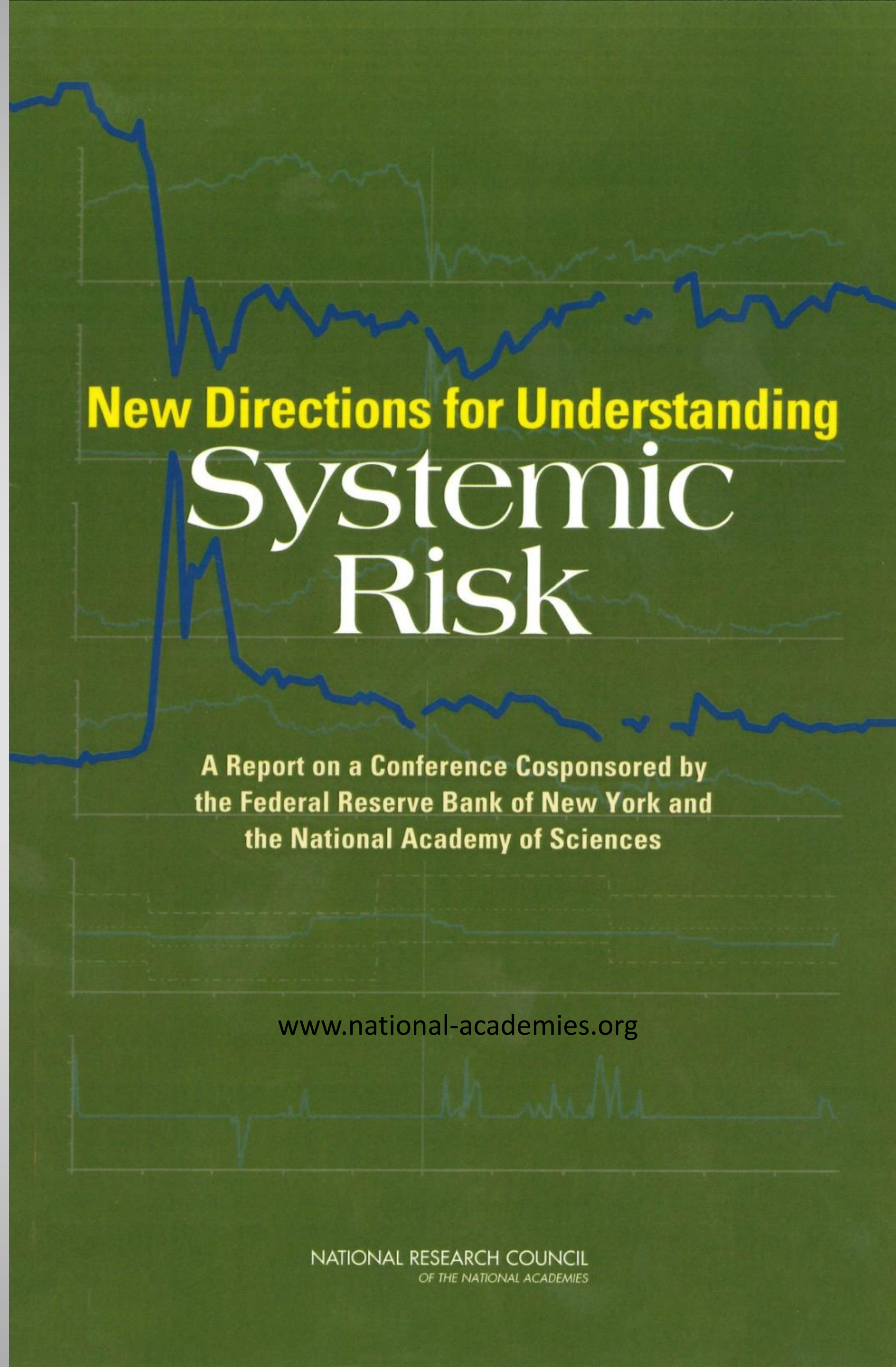
OUTLINE

- Complex networks & their stability,
- Dynamics of model financial systems,
- Regulatory implications.


New Directions for Understanding
Systemic
Risk
A Report on a Conference Cosponsored by
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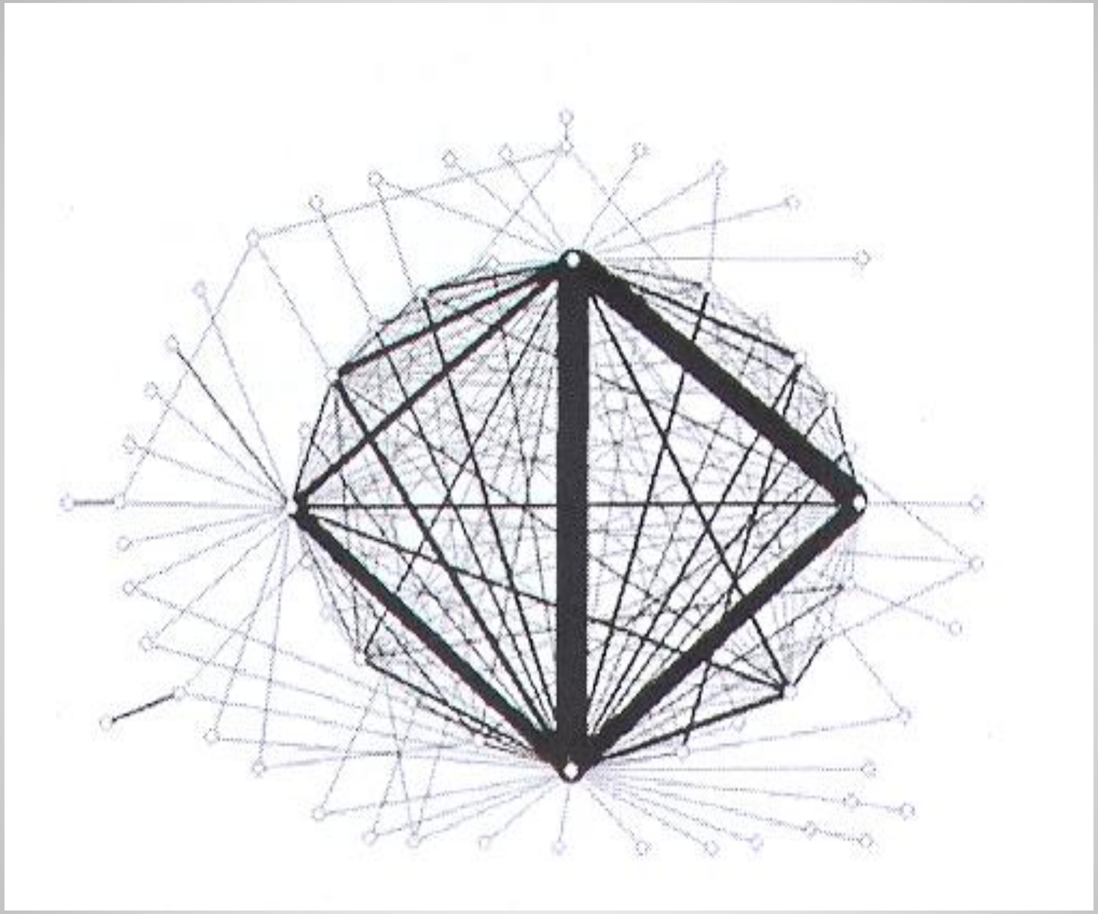
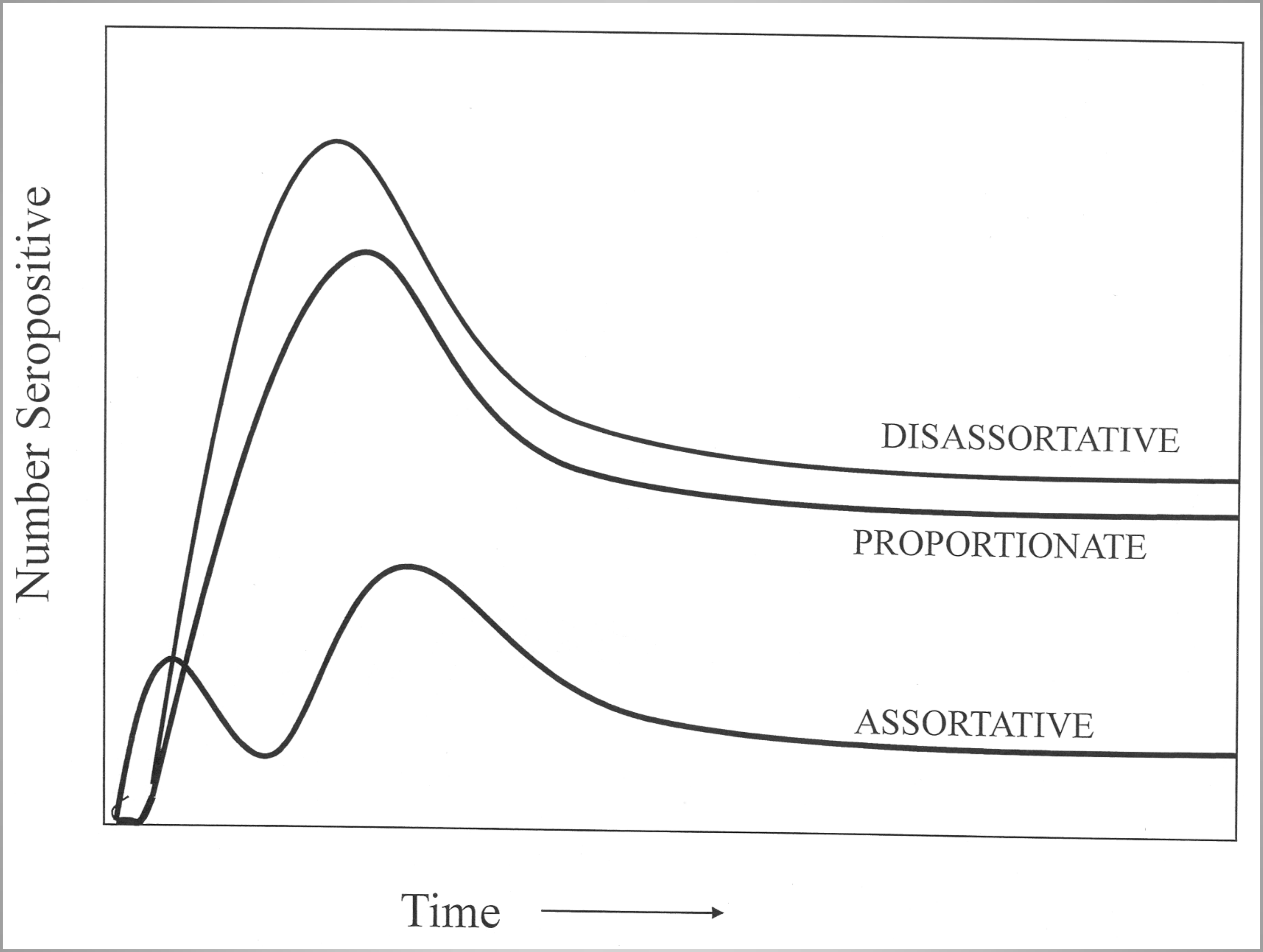


Caveat

Degree distributions, by themselves, do NOT uniquely specify the full structure of a network

To understand how a network will respond to disturbance, you need to know its connectivity structure: i.e. who is connected to whom.



From Gupta, S., Anderson, R. M. & May, R. M. 1989. *AIDS* 3, 807–817.

NETWORKS & INTERACTION STRENGTHS, A

Consider a community of N species, each with intraspecific mechanisms which, in isolation, would stabilize perturbations. Now let there be a randomly constructed network of interactions among these N species (with a mean number, m, of links per species, and each interaction, independently randomly, being + or – and with average magnitude α compared with the intraspecific effects).

NETWORKS & INTERACTION STRENGTHS, B

The overall stability of such a “randomly constructed” assembly explicitly depends both on the network’s connectance (number of links/number of possible links per species; C = m/N), and on the average interaction strength α. For large N, the system is stable if, and only if,

$$NC\alpha^2 = m\,\alpha^2 < 1$$

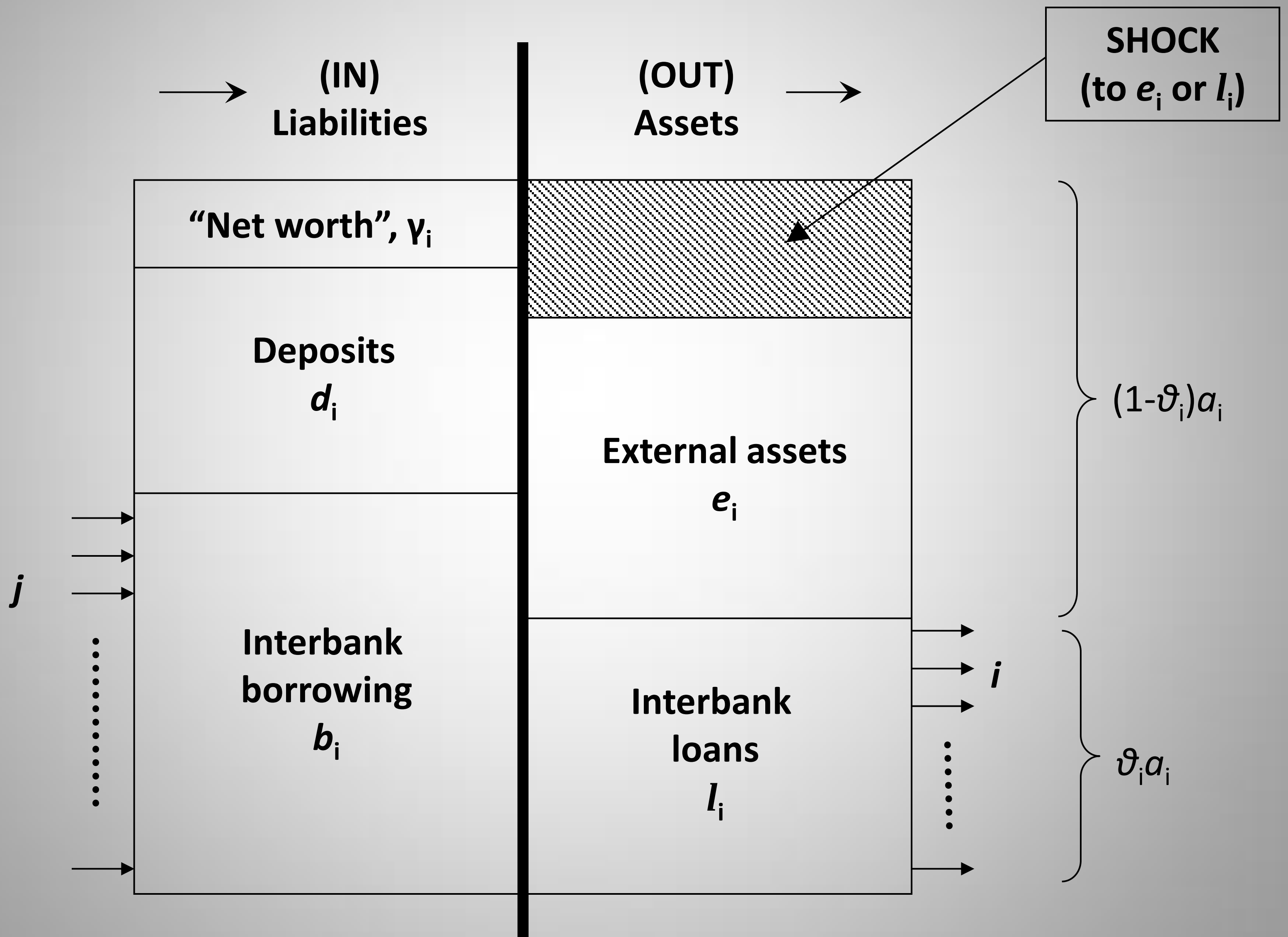
NETWORKS & INTERACTION STRENGTHS, C

Real food webs are, of course, not "randomly assembled" networks, but are the winnowed products of evolutionary processes.

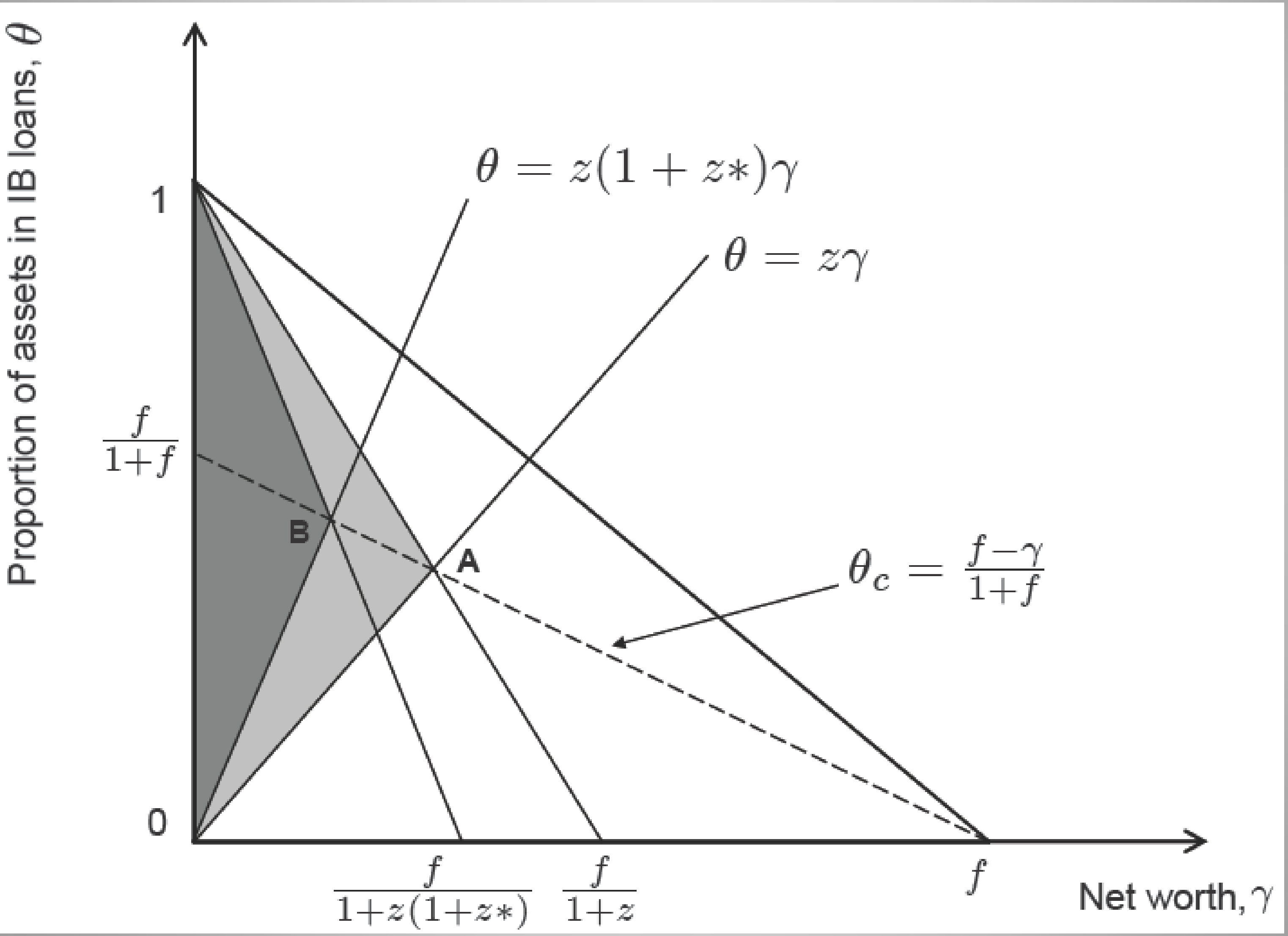
So the reshaped agenda has been to seek – in nature and in mathematical models – the special kinds of food-web/network structures that may help reconcile "complexity" with "systemic stability".

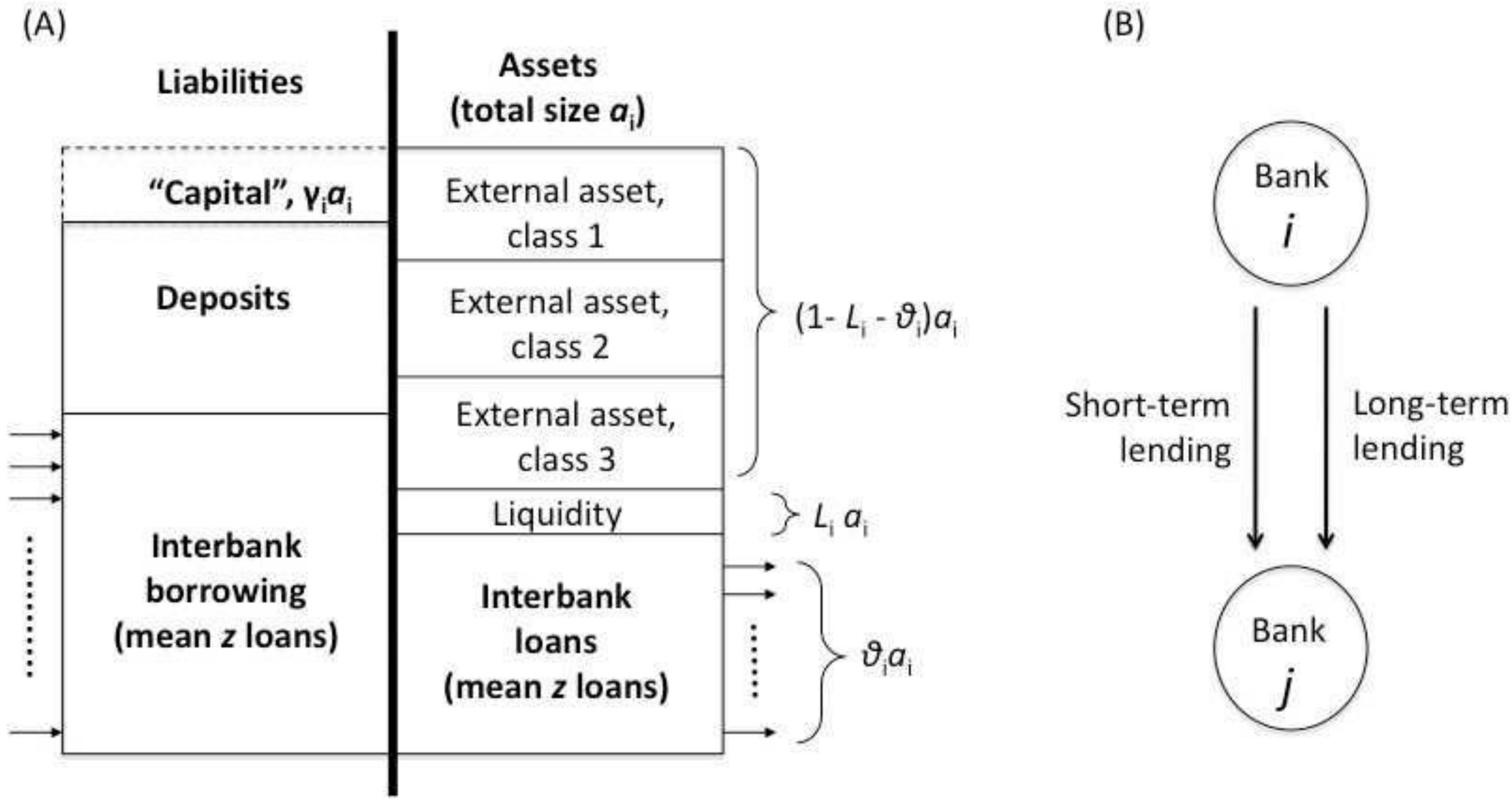
That fact that food webs tentatively reconstructed from paleo-data (Burgess Shale), by Dunne & Erwin (2008) seem similar to present-day ones – especially in predator-prey ratios – suggest there **is** something to be explained!

Schematic model for a 'node' in the interbank network



Regions of instability




(A)
Liabilities
Assets
(total size a_i)
"Capital", $\gamma_i a_i$
Deposits
Interbank
borrowing
(mean z loans)
External asset,
class 1
External asset,
class 2
External asset,
class 3
Liquidity
Interbank
loans
(mean z loans)
$(1- L_i - \vartheta_i)a_i$
$L_i\ a_i$
$\vartheta_i a_i$
(B)
Bank
i
Short-term
lending
Long-term
lending
Bank
j

Characterising "confidence", C, at the systemic level:

C = A × E, where

A ("solvency health") ≡ value of all assets/ initial value

E ("liquidity health") ≡ fraction of interbank loans NOT withdrawn

“Health” of individual bank *i*:

$$h_i = a_i\, m_i, \text{ where}$$

$a_i \equiv$ value of bank i’s assets/initial value

$m_i \equiv$ fraction of loans bank I can settle immediately, via liquidity or short-term assets.

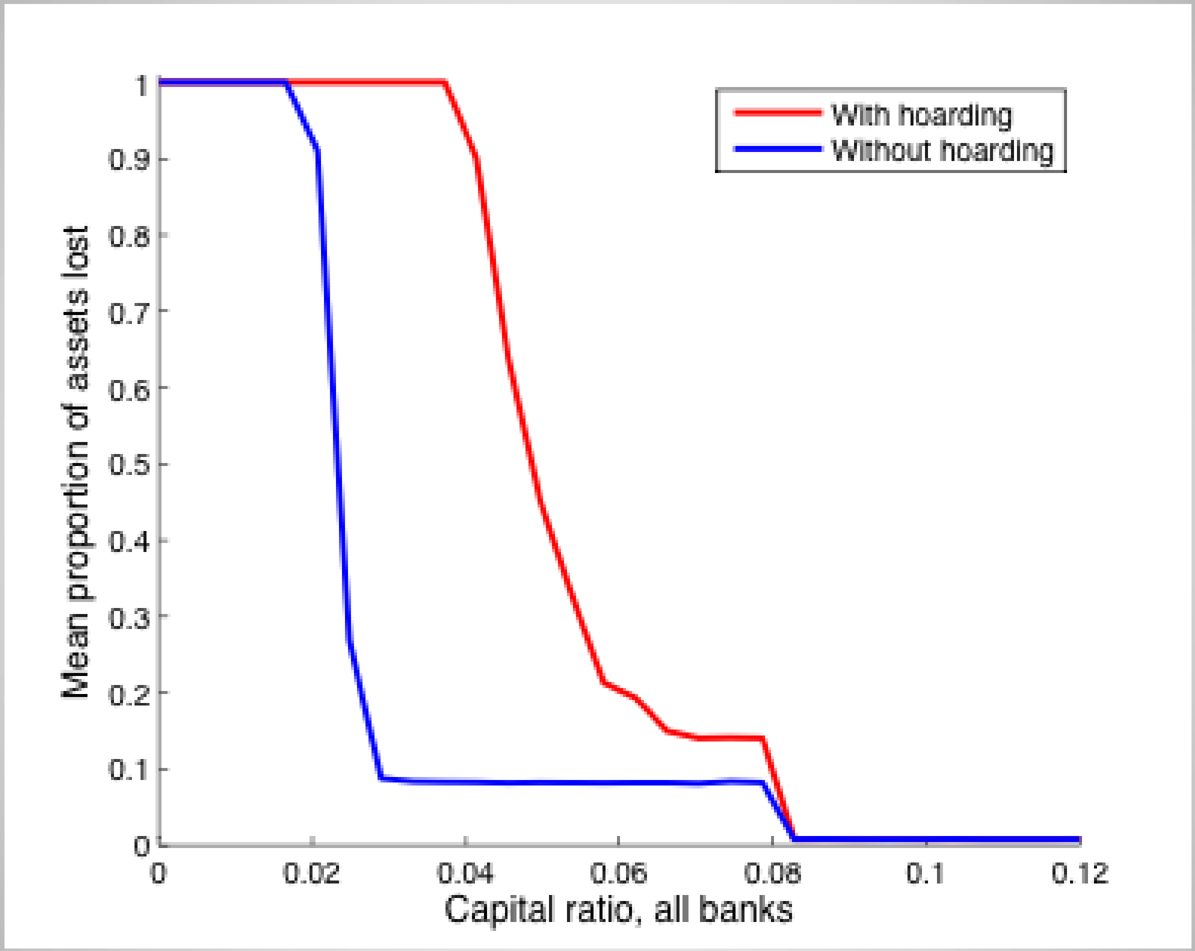
a_i is bank i’s analogue of system’s A;

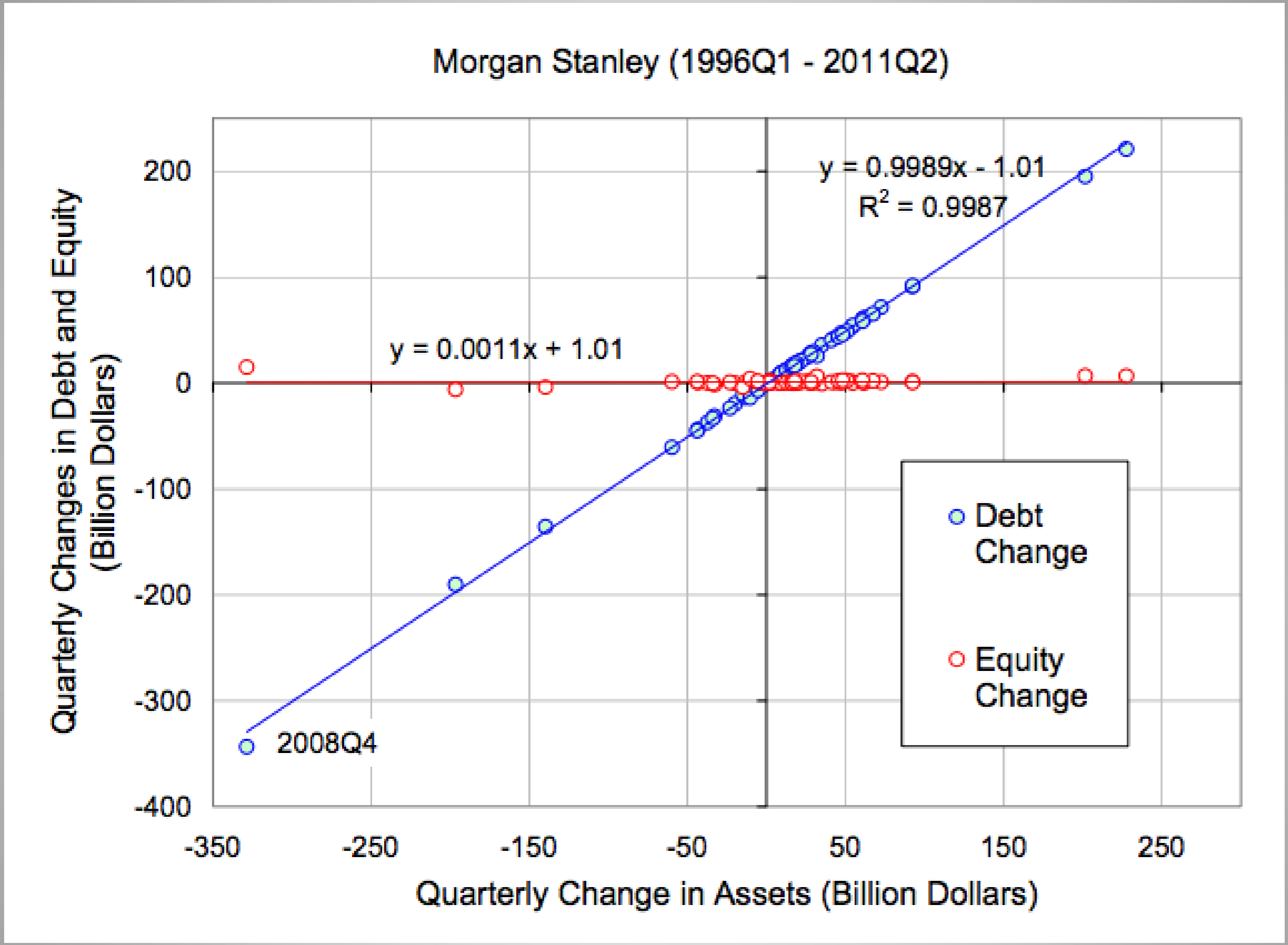
m_i reflects its liquidity position.

EFFECTS OF "CONFIDENCE" ON LOANS (Long and Short)

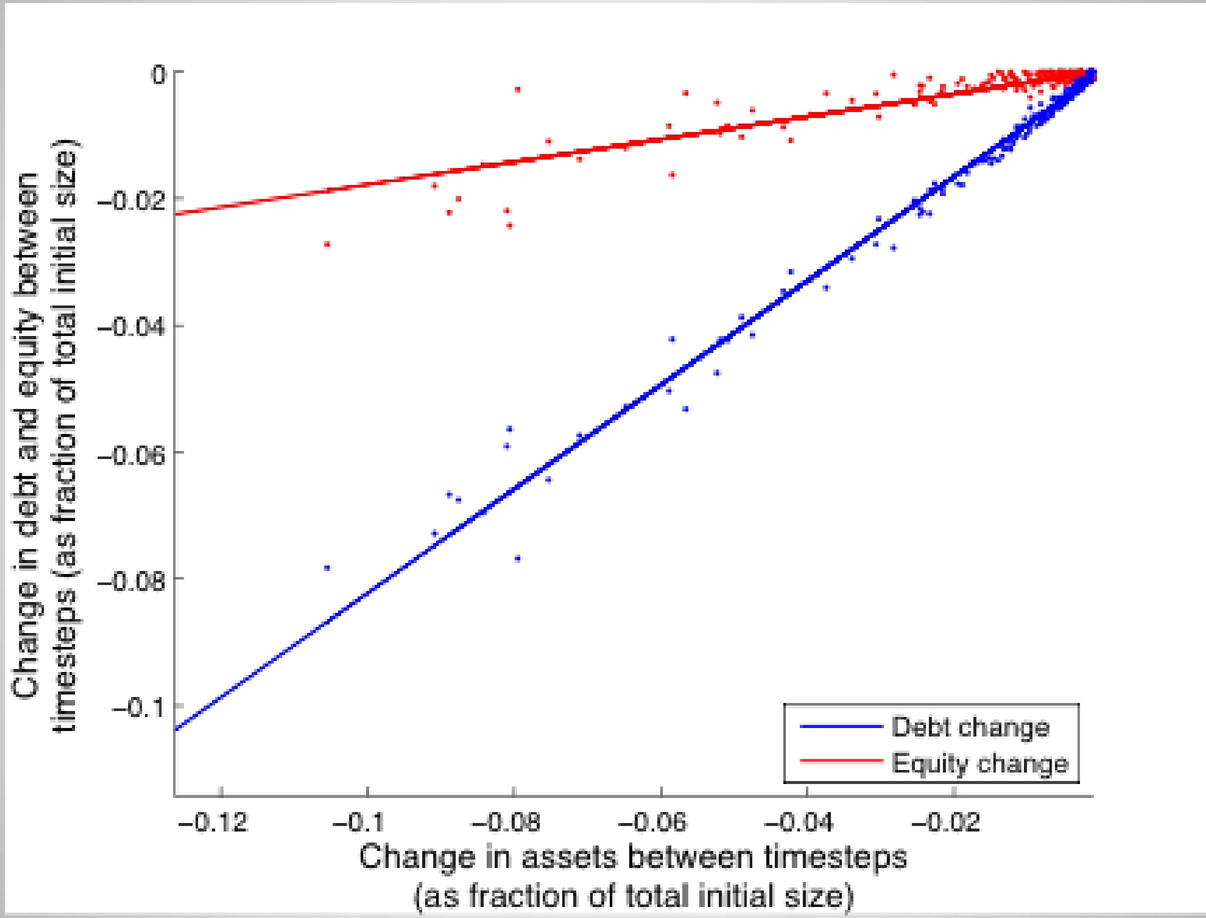
- If $h_i h_j < 1 - C$,
  Both banks long → short.

- If $h_i h_j < (1 - C)^2$
  Both banks "call in" all loans

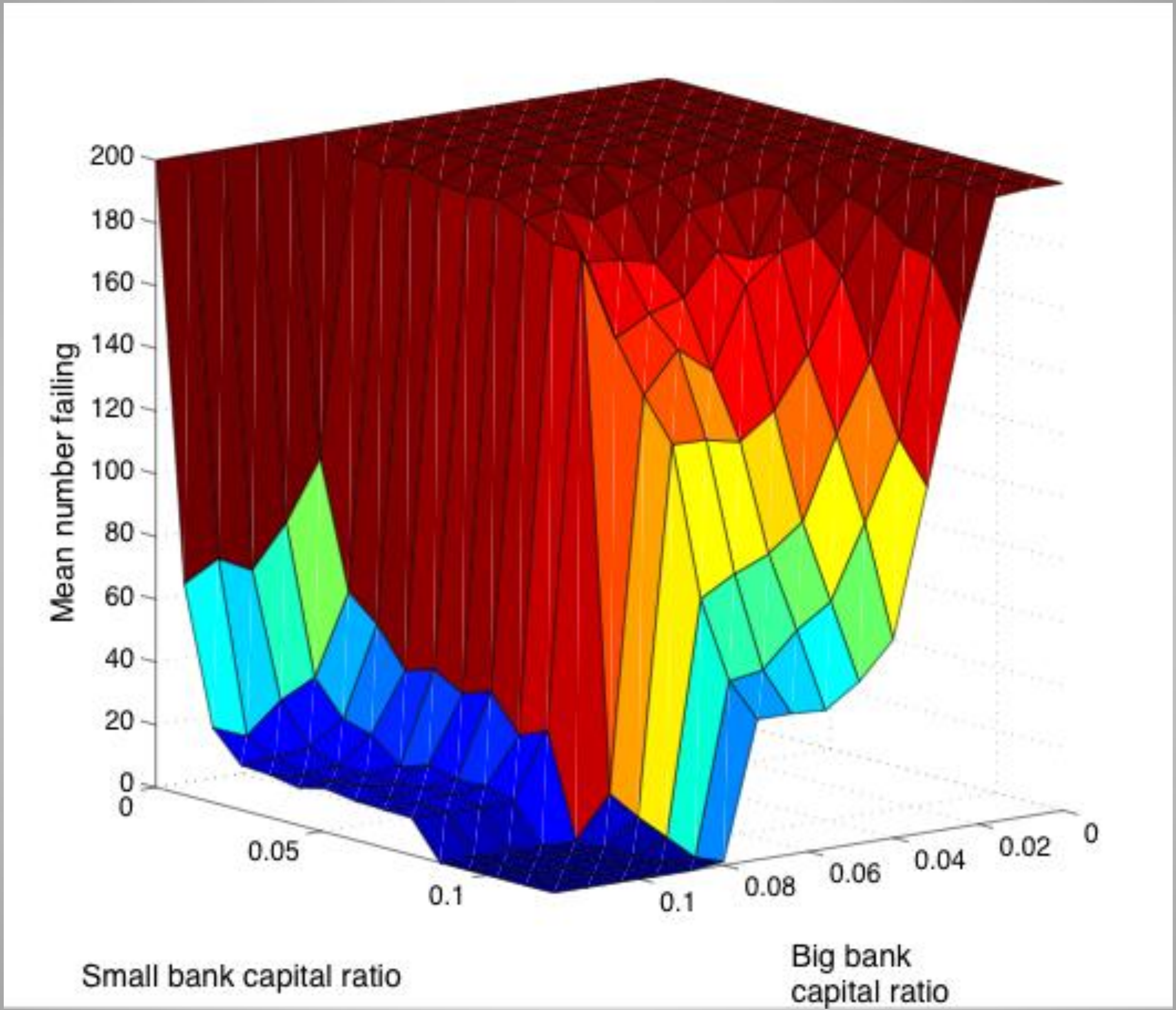

With hoarding
Without hoarding
Mean proportion of assets lost
Capital ratio, all banks
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.02
0.04
0.06
0.08
0.1
0.12



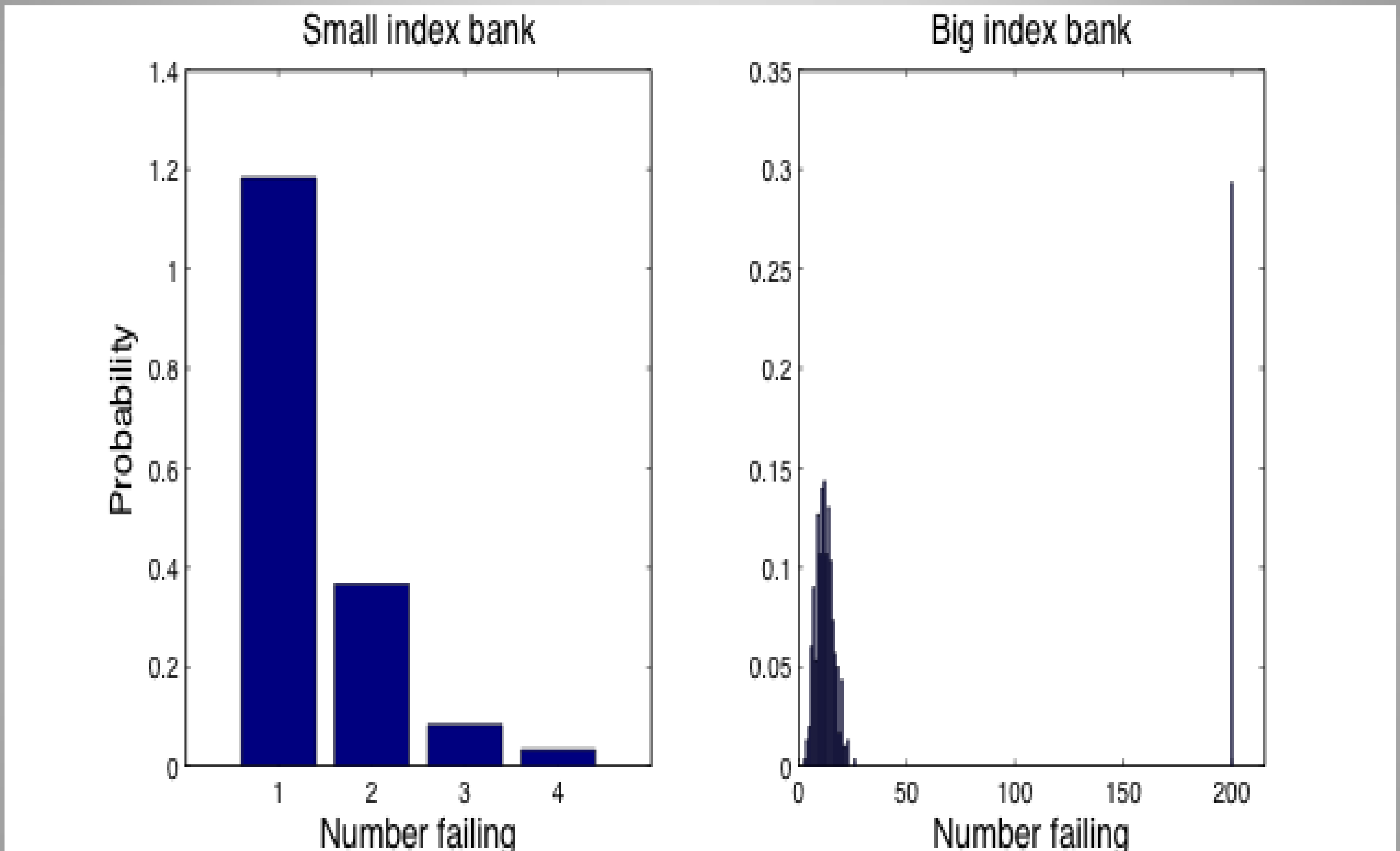
From Shin, H. (2010) Risk and Liquidity (Clarendon lectures in finance)



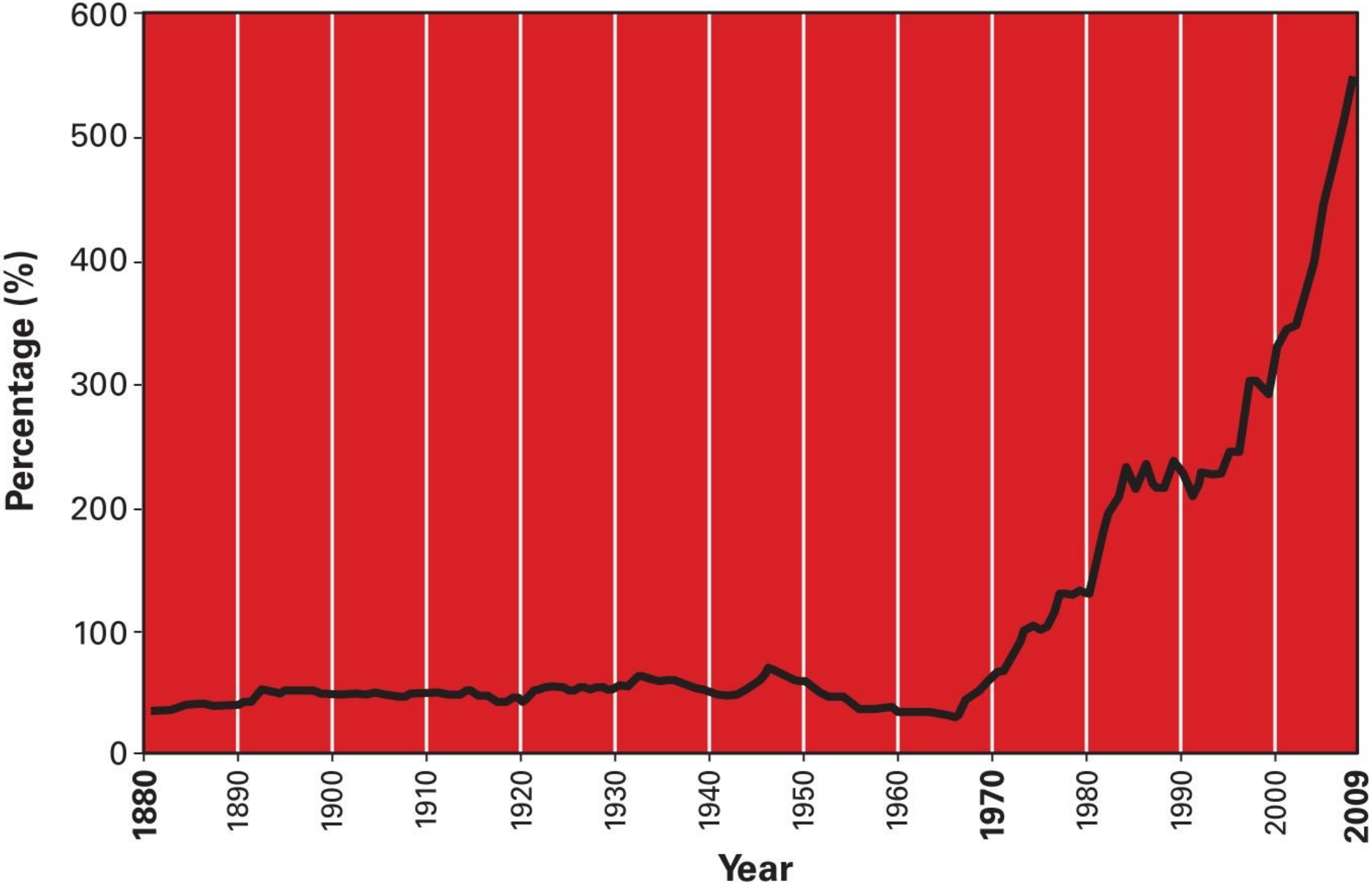
Change in debt and equity between timesteps (as fraction of total initial size)
0
−0.02
−0.04
−0.06
−0.08
−0.1
−0.12
−0.1
−0.08
−0.06
−0.04
−0.02
Change in assets between timesteps (as fraction of total initial size)
Debt change
Equity change



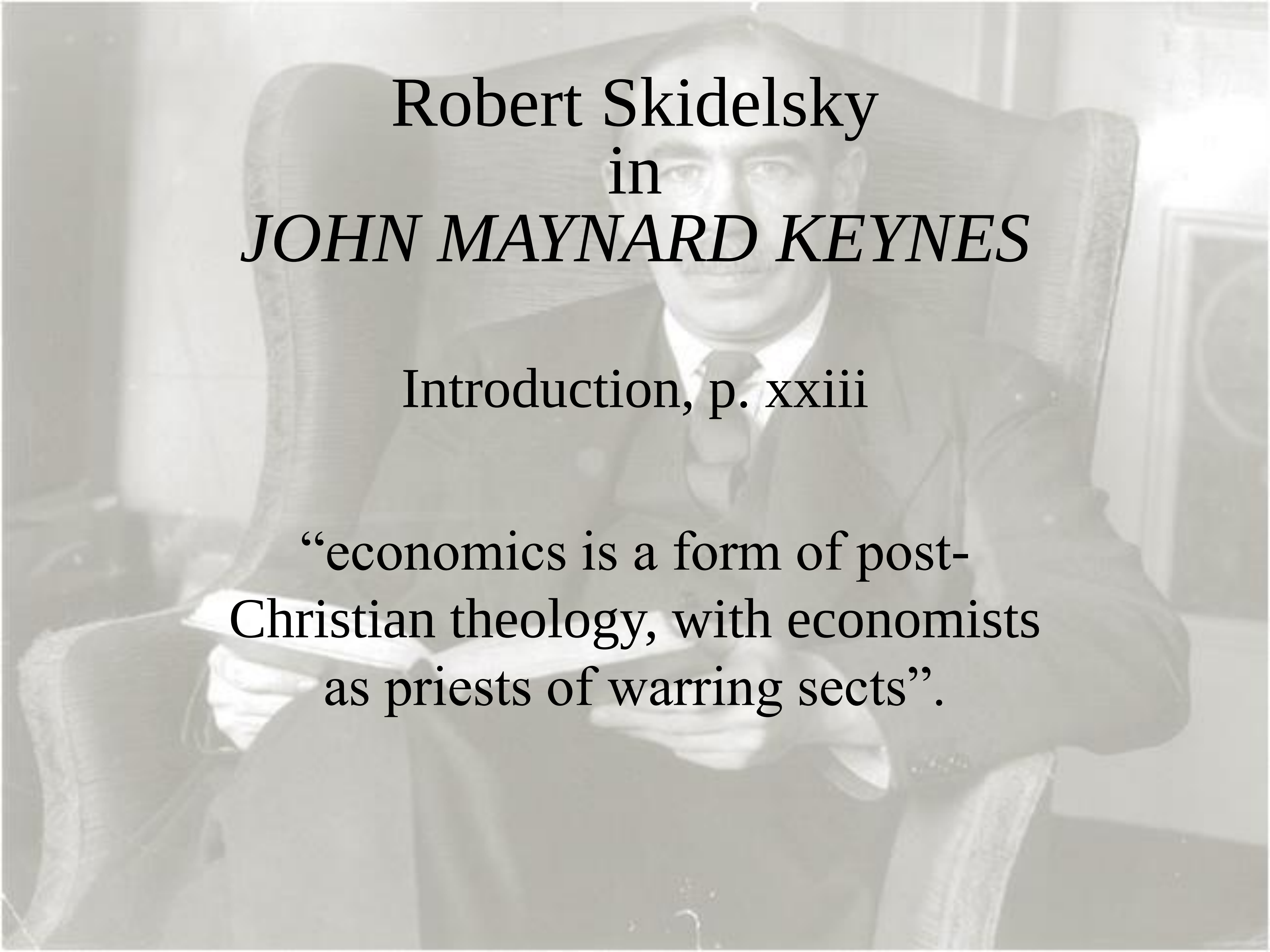
200
180
160
140
120
100
80
60
40
20
0
Mean number failing
0
0.05
0.1
0.1
0.08
0.06
0.04
0.02
0
Small bank capital ratio
Big bank
capital ratio



Small index bank
Probability
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
Number failing
Big index bank
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
Number failing



UK Bank Assets/GDP



Robert Skidelsky
in
JOHN MAYNARD KEYNES

Introduction, p. xxiii

“economics is a form of post-Christian theology, with economists as priests of warring sects”.

The market in financial derivatives is essentially a complex network of non-linear interdependencies among players, where individual incentives are often at odds with global stability. This market grew – and is again growing – in size and complexity, with essentially no discussion of its potential impact on the economy as a whole.

Derivatives are financial contracts between two parties, where the value of the payoff is derived (hence the name) from the value of another security. For example, in a CDS one party could buy from a second protection against the default of a third party to which it has lent money. It was argued this stabilises markets, by “sharing risk”. In general, such a derivative is like a bet on some future event, without the need to put cash on the table!

The net result is to amplify payoffs (both positive and negative) that would be obtained by trading the underlying security. Hence figure 1.

Because the players can engage in an unlimited number of confidential bets with other players, the derivative market is essentially a complex financial network, whose structure is not observable, and with non-linear interactions among the nodes. Mathematical studies in other areas, particularly on the structure and dynamics of ecosystems, have shown that such complex non-linear dynamical systems are prone – beyond some threshold – to cascading instabilities (the May-Wigner Theorem).

APT: 1

APT draws from the mythological landscape of mathematical economics, assuming:

- “perfect competition”
- market liquidity
- “no-arbitrage”, i.e. the nonlinear interplay between trading and the dynamics of financial markets can be ignored

In good times, the expanding market is such that financial instruments indeed seemed to produce the “arbitrage-free” and “complete” market which APT hypothesizes.

APT: 2

As Caccioli, Marsilli & Vivo clearly show, using a deliberately simplified model (“ a caricature of markets”), although “the introduction of derivatives makes the market more efficient, competition between financial institutions naturally drives the market to a critical state characterized by a sharp singularity.”

Such derivative instruments are traded over-the-counter (OTC), and in the absence of an exchange market are opaque. Moreover, such derivative contracts can be made arbitrarily complex: it has been variously estimated that, were such a contract presented in the older idiom of “prospectus”, it could run to 10^6 or even 10^9 pages!

Four key reforms have been proposed: (a) to make derivatives more transparent; (b) to have them traded over exchanges; (c) to ensure that they are not written by government insured entities; and (d) to end the priority that they receive in bankruptcy. Reform (c) would reduce the hidden subsidy they receive from the public. Reform (b) would make information on prices, volumes and exposures available to regulators and the public.

CAPITAL RESERVES

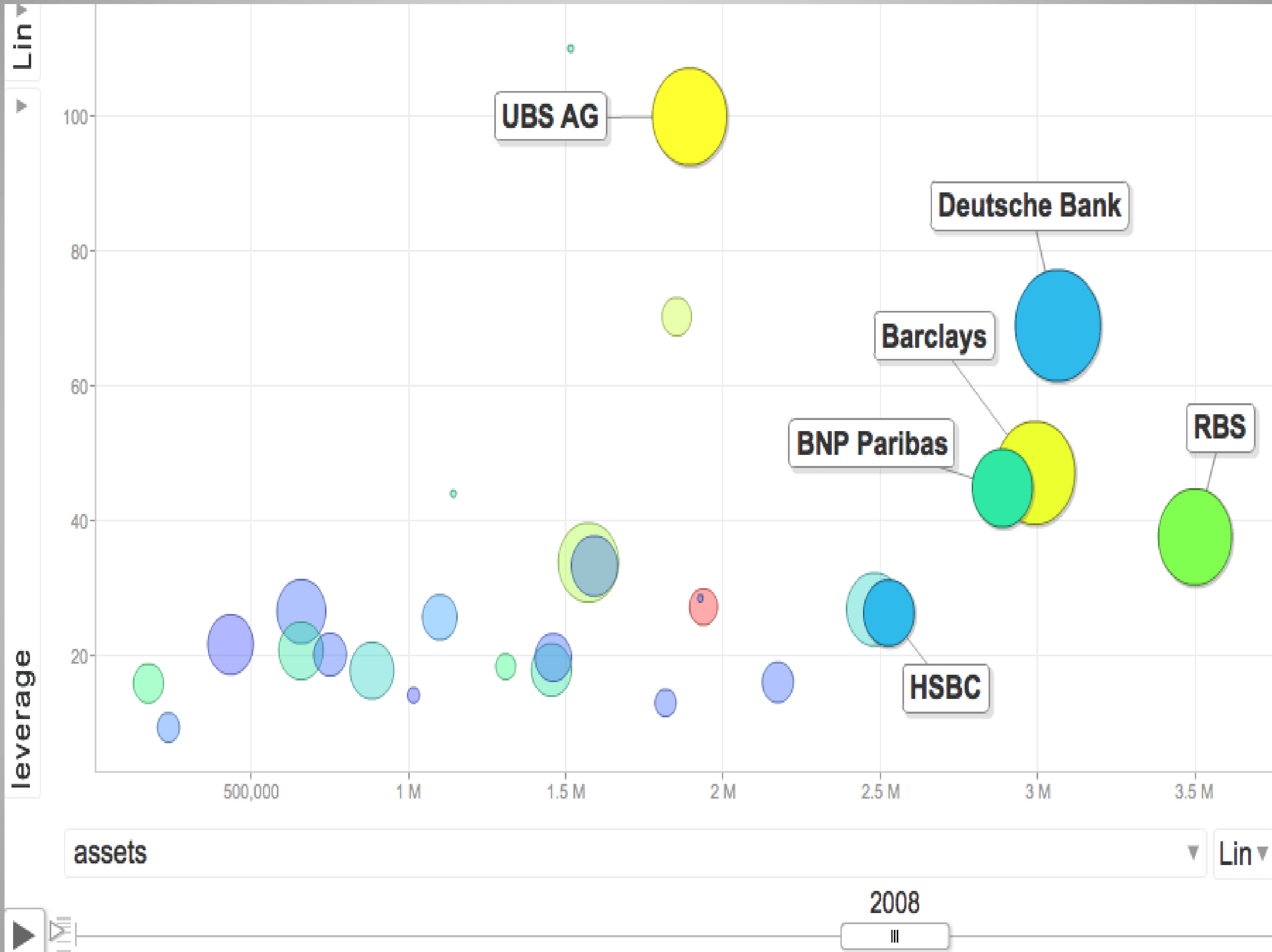
- Large capital reserves allow greater robustness of both individual banks and of the system as a whole
- Arguably, capital reserves should be relatively larger in boom times, when the temptation to take greater risks seems prevalent.
- *System stability* - bigger banks should hold their ratio of capital reserves to total assets at least as high as smaller banks.
  - In practice the contrary is observed.

LEVERAGE LIMITS

“One simple means of altering the rules of the asymmetric game between banks and the state is to place heavier restrictions on leverage. …

“This is an easy win. Simple leverage ratio [rules] already operate in countries such as the US and Canada. … Leverage rules … need to be robust to the seductive, but ultimately siren, voices claiming this time is different”.

Haldane, Nov 2009


UBS AG
Deutsche Bank
Barclays
BNP Paribas
RBS
HSBC
100
80
60
40
20
500,000
1 M
1.5 M
2 M
2.5 M
3 M
3.5 M
leverage
Lin
assets
Lin
2008

CENTRAL CLEARING FOR COUNTERPARTIES

CCP stands between "Over the Counter" traders ("counterparties"), insulating them from each other's default.

CCP can reduce systemic risk by:

(i) providing greater transparency;

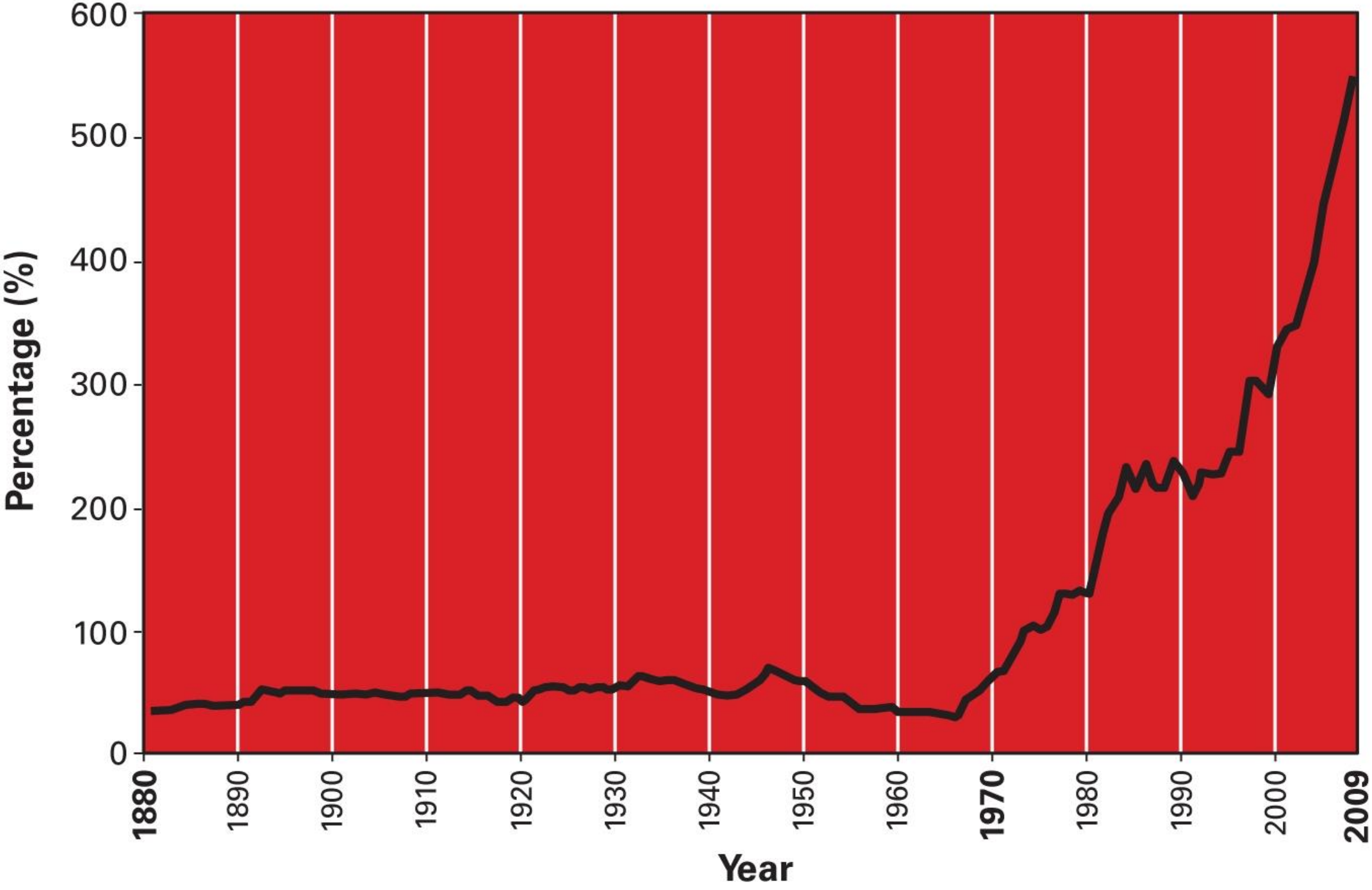
(ii) reducing "Fire Sales", cascades, and market disruption more generally.

But there are some unresolved problems.

"RECONSIDERING THE INDUSTRIAL ORGANIZATION OF BANKING"

In ecosystems, "modular organization" is often seen, and promotes systemic robustness.

This echoes the Glass-Steagal Legislation of 1933, or the recent Volker rule; perhaps "High Street Banks" should not take depositors' money to the casino.



UK Bank Assets/GDP

MORE GENERALLY

Benjamin Friedman (Bull. Am. Acad., Spring 2011) observes that: “Thirty years ago, the cost of running the financial system was 10 percent of all of the profits earned in America. Fifteen years ago, the financial system cost somewhere between 20 and 25 percent of all profits earned in America. In the first half of this decade, before the crisis hit, running the financial system took one-third of all profits earned on investment capital.”

The basic purpose of the financial system is to allocate capital efficiently in a free-market system. But – says Friedman – **“The time has come… to ask how much it is costing us to operate this financial system.”**

FURTHER READING

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- Arinaminpathy, N. *et al*. Size and complexity in model financial systems. *PNAS*, **109 (45)**, 18338-18343 (2012)
- May, R.M. Financial Ecosystems can be vulnerable too. *Financial Times*, op-ed, 19 October (2012)
- Battiston, S., Stiglitz, J. *et al*. The complexity of derivative networks. *Nature Physics*, in press (2013)
- Caccioli, F., *et al*., Eroding market stability by proliferation of financial instruments. *Eur. Phys. J. B.*, **71**, 467-479 (2009).
- Sugihara, G., *et al*., Detecting causality in complex ecosystems. *Science*, **338**, 496-500 (2013).