Liquidity Risk and Contagion

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Two Themes

- Liquidity risk in a system context

- Counterparty risk

Background

- Mark-to-market accounting of assets

- Prudential constraints on discretion
  – Capital requirements
  – Risk-management systems

Liquidity Risk in a System Context

- Price impact of sales/purchases
- Externalities – impact on *other* players
- Feedback when combined with constraints on discretion
- Liquidity as a public good

Counterparty Risk

- Balance sheet interlinkages
- Value of claim against *A* depends on value of *A*'s claims against others…
- Counterparty risk is endogenous
- Depends on
  – market liquidity
  – leverage
  – network of interconnections

Mark to Market Accounting

- Transparency
  - *Ex ante* incentives, moral hazard
  - Measurement of counterparty risk
- But *measurement* implies *actions*
  - Reacting to price changes
  - Amplifying price changes
  - *Measuring* counterparty risk *determines* counterparty risk

Channels of Contagion

- Balance sheet interlinkages
  - "Domino" models/simulations show very little contagion
- Price effects
  - Even without B/S interlinkages, contagion can be potent (European insurers, summer 2002)
  - Makes B/S interlinkages very potent

Framework

- n "banks"
- notional liabilities matrix:

$$L \equiv \begin{bmatrix} 0 & L_{12} & \dots & L_{1n} \\ L_{21} & 0 & \dots & L_{2n} \\ \dots & \dots & \dots & \dots \\ L_{n1} & L_{n2} & \dots & 0 \end{bmatrix}$$

Payments

$$\begin{bmatrix} 0 & x_{12} & \dots & x_{1n} \\ x_{21} & 0 & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{n1} & x_{n2} & \dots & 0 \end{bmatrix}$$

x_i is total payment by bank *i*

$$x_{ij} = x_i \left(L_{ij} / \sum_k L_{ik} \right) \quad \text{(pro rata payments)}$$

Balance Sheet

- Net worth of bank *i*

$$pe_i + c_i + \sum_k x_{ki} - x_i$$

  – *pe* market value of illiquid asset
  – *c* is liquid asset (price = 1)

Clearing Vector *x*

$$x_i = \min\left\{\bar{x}_i, pe_i + c_i + \sum_k x_{ki}\right\}$$

$$x = \bar{x} \wedge \left(w(p) + \Pi^T x\right)$$

Unique fixed point $x(p)$

Eisenberg and Noe (2001)

Capital Adequacy Ratio

$$\frac{pe_i + c_i + \sum_k x_{ki} - x_i}{p(e_i - s_i) + (c_i - t_i) + \sum_k x_{ki}} \geq r^*$$

top: net worth

bottom: marked-to-market assets, after

s sale of illiquid asset

t sale of liquid asset

Sales function $s(p)$

- When capital adequacy constraint binds, bank *i* sells illiquid assets:

$$s_i(p) = \min\left\{ e_i, \frac{\sum_j x_{ij} - (1 - r^*)\left(\sum_j x_{ji} + pe_i\right) - c_i}{r^* p} \right\}$$

$$s(p) = \sum_i s_i(p)$$

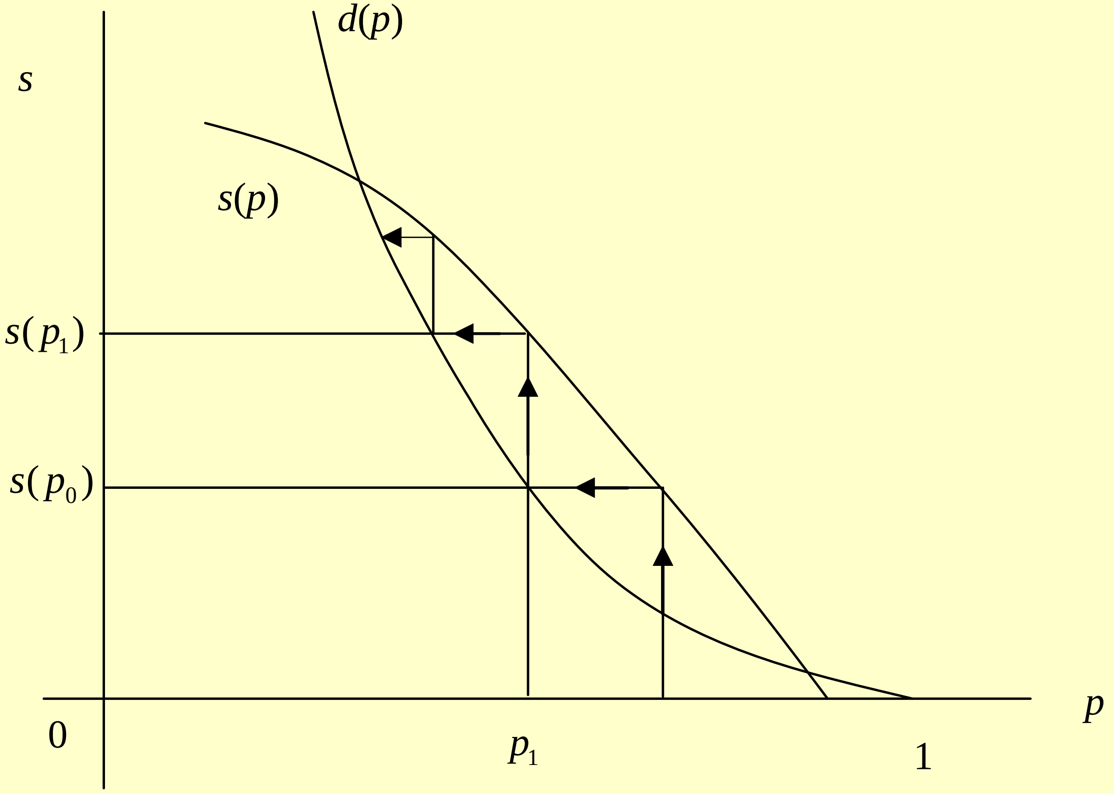
Demand for Illiquid Asset

- Downward sloping demand *d*(.) for illiquid asset so that

$$p = d\left(\sum_i s_i\right)$$

- Rationale

Price Dynamics



Equilibrium Price

$$\Phi(p) \equiv d^{-1}(s(p))$$

= market-clearing price of illiquid asset when balance sheets are evaluated at price *p*.

Equilibrium is a fixed point of $\Phi(p)$

Numerical Simulation

- 10 Banks
- Negative exponential demand function
- $r^* = 7\%$
- Initial shock to one bank (LGD)

Liquid and illiquid assets	70	Equity	7
Interbank assets	30	Deposits	63
		Interbank liabilities	30
Total assets	100	Net worth and liabilities	100

Algorithm

Capital adequacy satisfied?

- No, but net worth is positive
  - Sell liquid, then illiquid assets
- No, and net worth is zero
  - Liquidate bank, loss shared pro rata

Keeping Track of Price

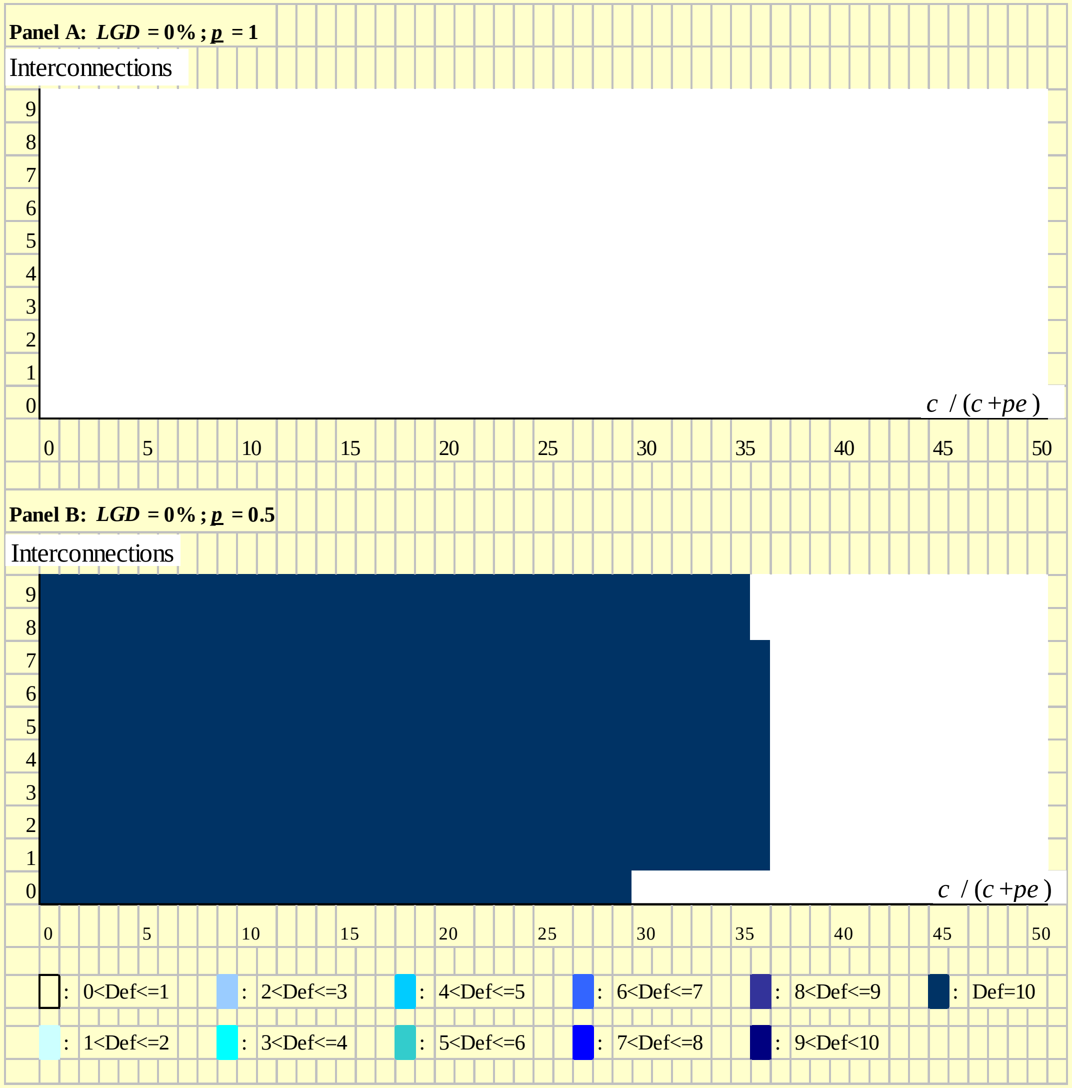
Mark-to-market rules

- Mark illiquid asset to market
- Check banks' solvency under the new price
- Iterate until an equilibrium price is found

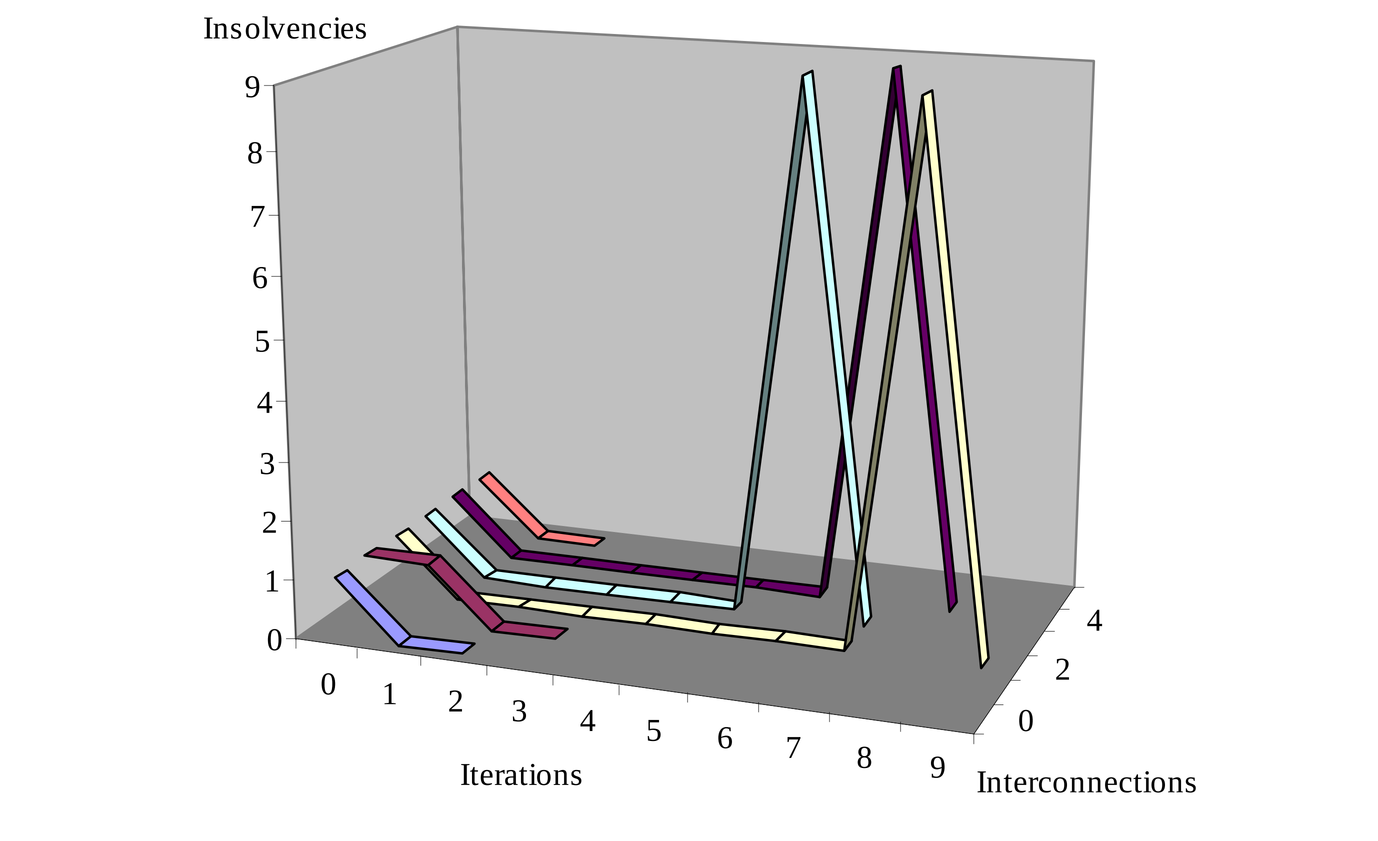
Network Structure

- Fix number of interconnections
- Average over all configurations (similar to random graphs)
- Tradeoffs
  - Large number of connections enable buffering of shocks
  - But many channels of transmission

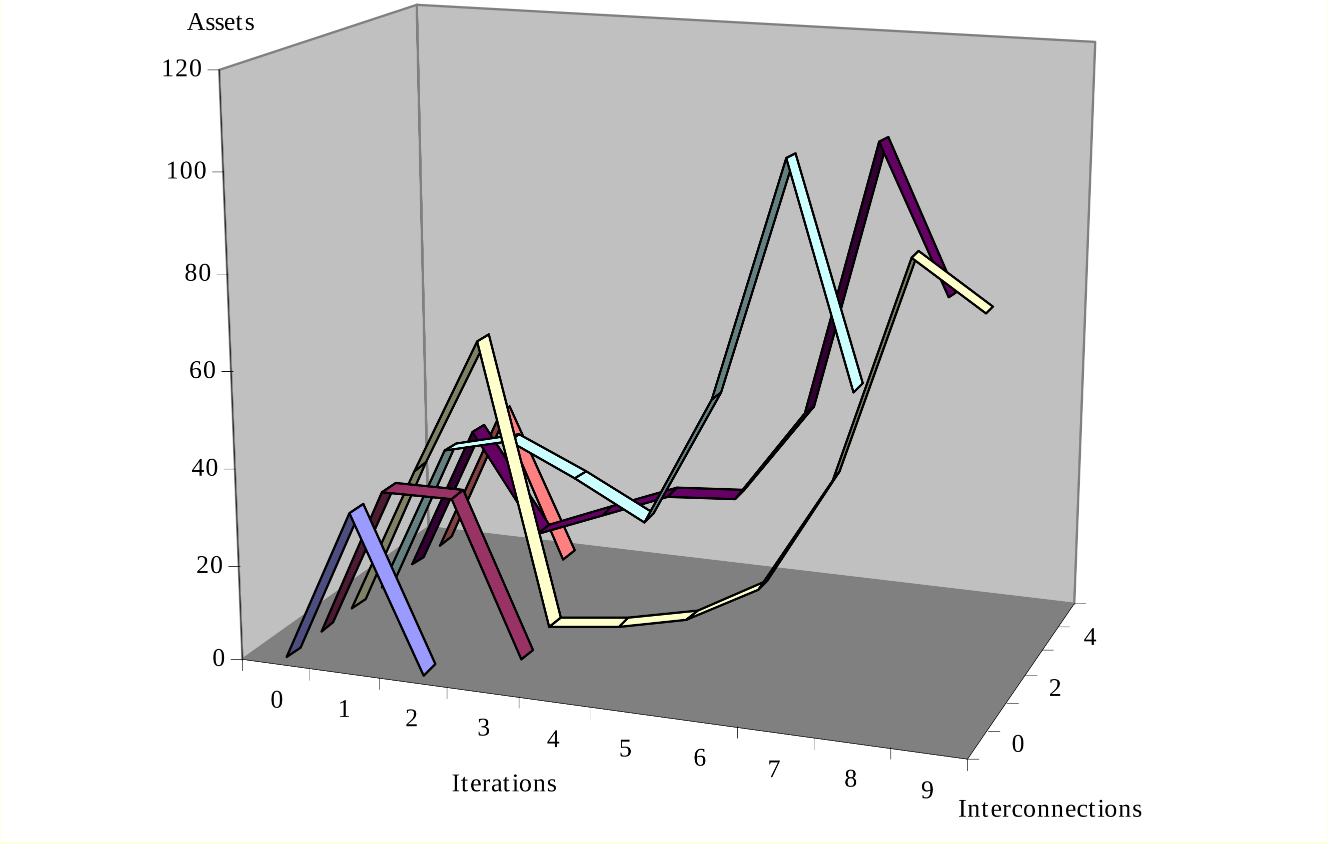
Example: Single failure, initial LGD = 0



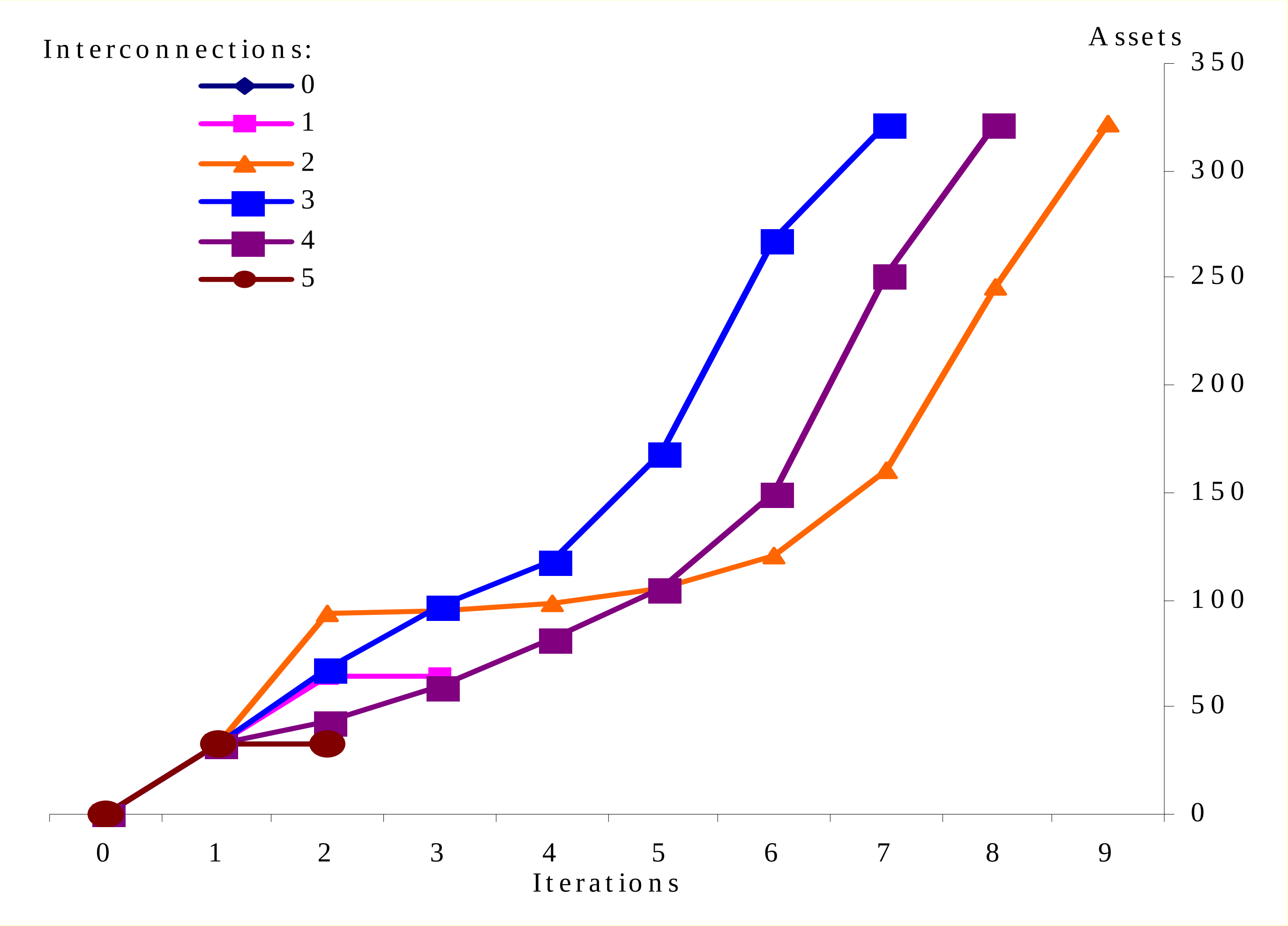
Insolvencies at Each Round



Assets Sold at Each Round

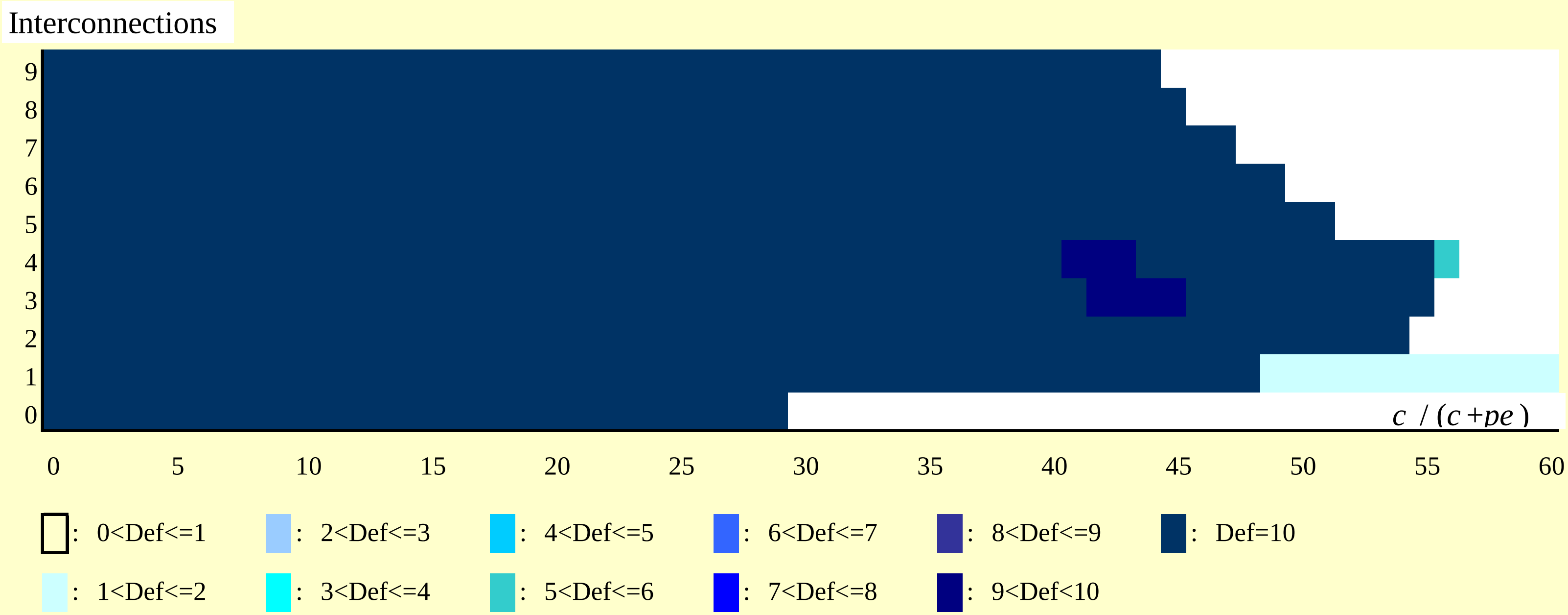


Asset Sold in Each Round

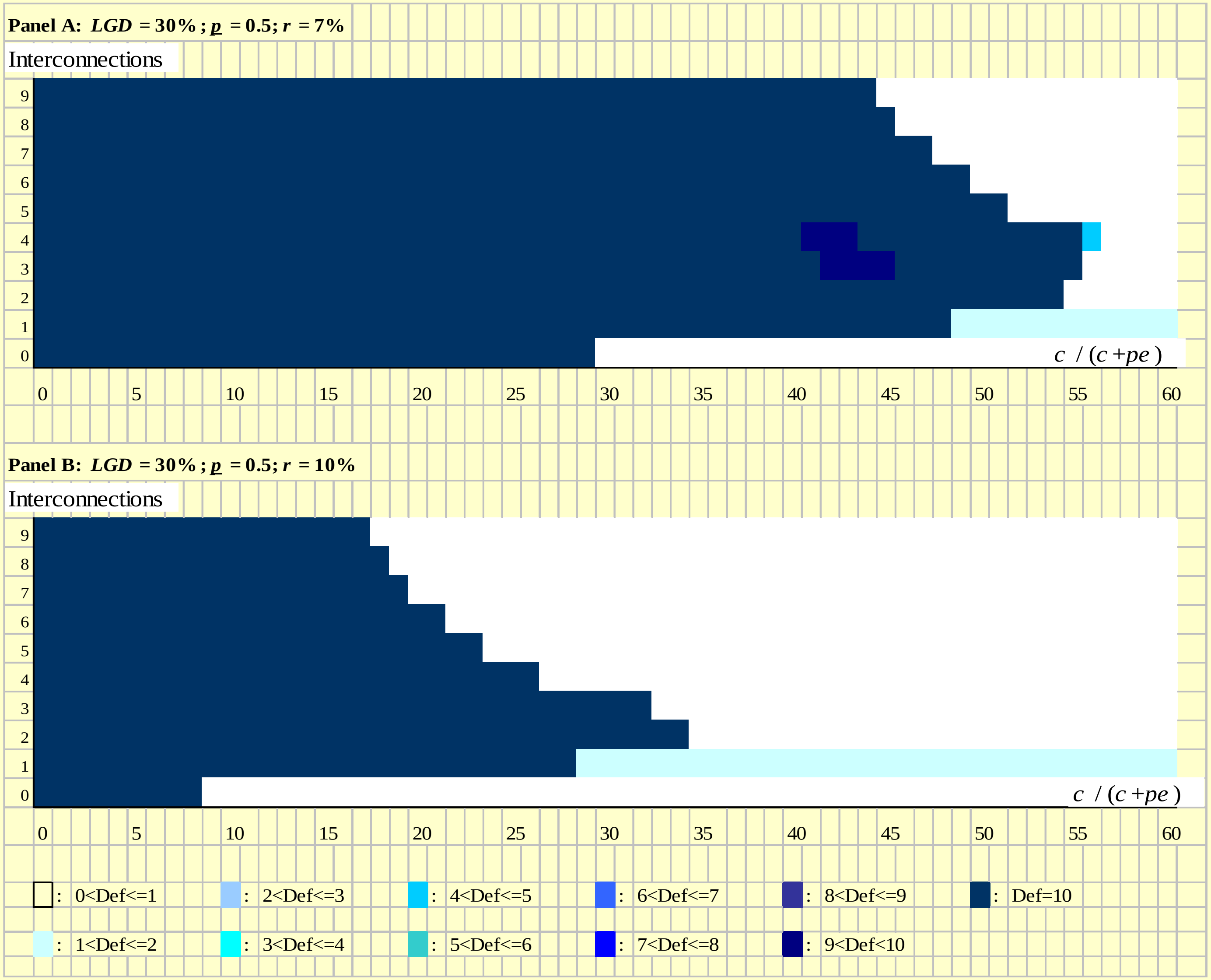


Role of Liquidity Buffer

Panel A: *LGD* = 30%; *p* = 0.5

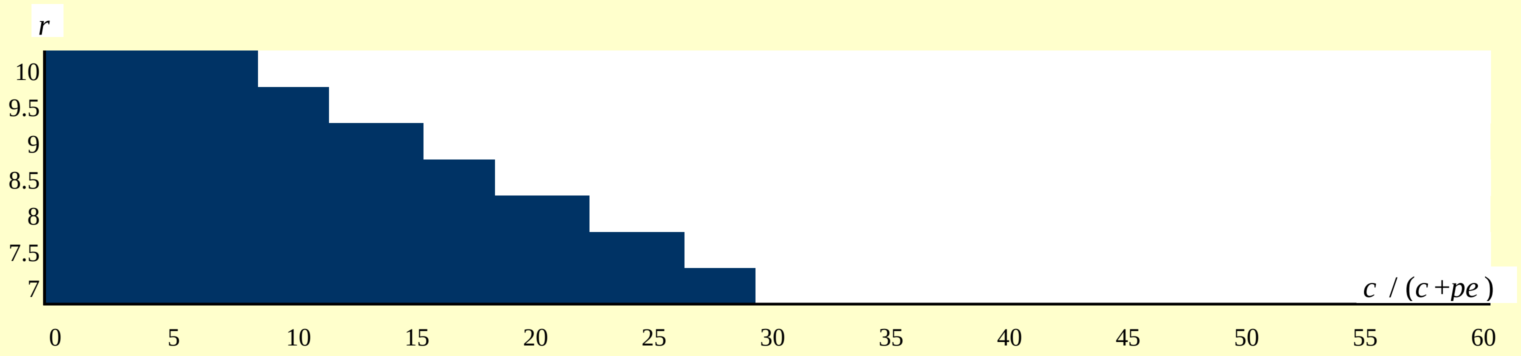


Role of Capital Buffer

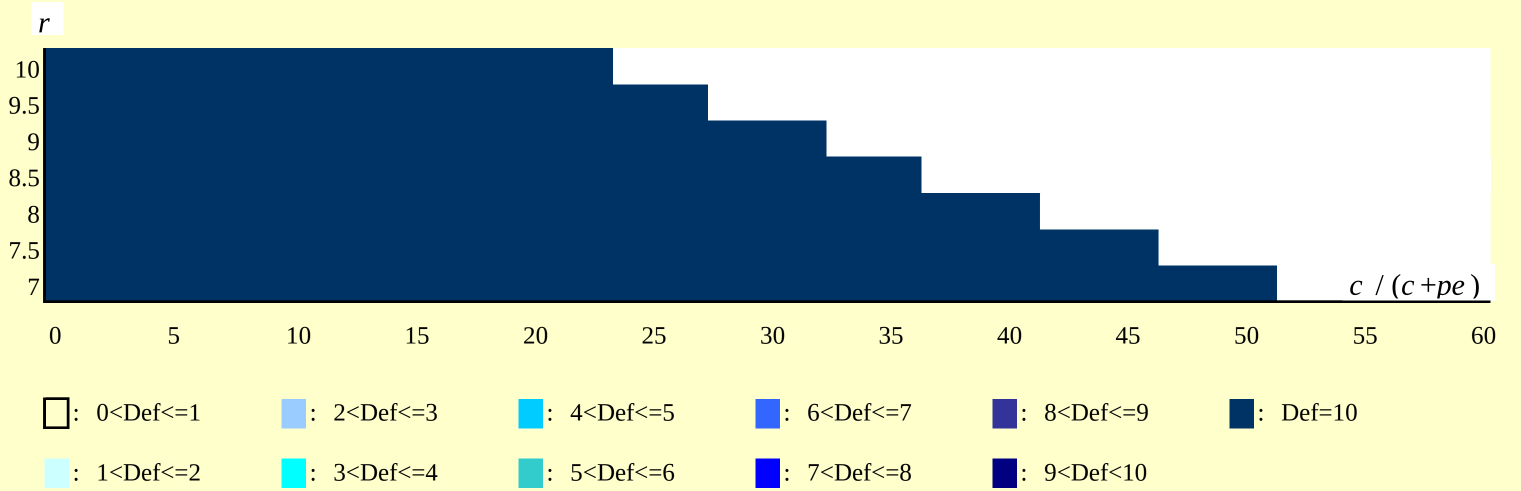


Liquidity versus Capital

Panel A: *LGD* = 30%; *p* = 0.5; Connections = 0



Panel B: *LGD* = 30%; *p* = 0.5; Connections = 5



Asset Composition

- Asset composition affects
  - bank’s intrinsic creditworthiness
  - capacity to withstand shocks
  - susceptibility to contagion

- In particular, liquidity affects
  - Resilience to shocks
  - Susceptibility to contagion
  - Externalities on the rest of the system

Tentative Lessons

- Contagion is greatest for small, but positive number of interconnections
- Multual reinforcemement of
  - Credit risk
  - Liquidity risk
  - Counterparty risk

Liquidity as a Public Good

- Some *ex ante* incentive to hold liquid assets
- But not all externalities will be internalized
  - – Sub-optimal liquidity
  - – Public good provision
  - – Liquidity requirement as a Pigouvian tax

Liquidity versus Capital

- Capital requirement is tax based solely on
  - assets of that bank
- Optimal Pigouvian tax is a function of
  - assets of that bank
  - liabilities of that bank
  - assets and liabilities of *all* banks
- Liquidity tax is closer to Pigouvian tax