

# Liquidity and Solvency Shocks in a Network Model of Systemic Risk: The Impact of Minimum Capital and Reserve Requirements

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- 1 The idea
- 2 The model
- 3 The simulations
- 4 Summary

# The issue

- Recently proposals have been implemented to increase capital requirements for banks
- Minimum liquidity requirements have also been introduced
- Are these general measures effective?
- Should more sophisticated requirements be developed?

# The rules

- Basel II: tier 1 capital is 4% of risk weighted assets
- Basel III: tier 1 capital is 8.5% of risk weighted assets plus 2.5% discretionary countercyclical buffer
- Leverage maximum 3% of unweighed assets
- In addition requirements on liquidity to cover net cash outflows for 30 days

# Our contribution

- Use a network of heterogenous banks
- Different sizes, different interbank loans, different networks,....
- Explore how capital and liquidity requirements reduce systemic risk and the risk of individual bank failure

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# Balance sheet of banks

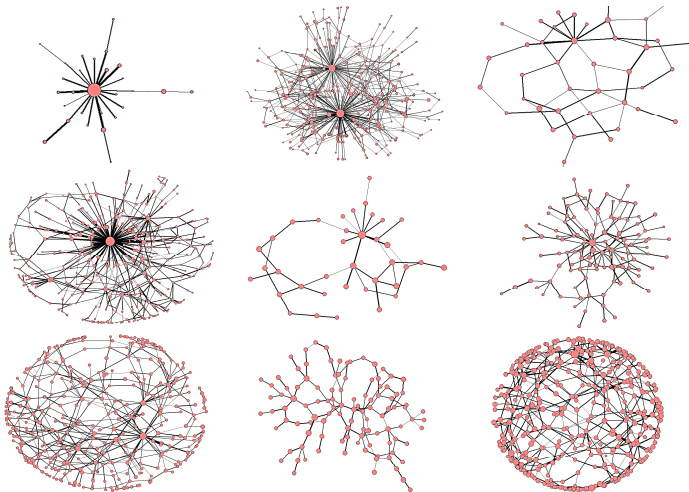
Assets ( $A_i$ )		Liabilities	
Cash ( $R_i = \rho_i A_i$ )	Excess cash ( $R_{\text{excess}} = \rho_{\text{excess}} A_i$ )	Deposits ( $D_i = \gamma_i A_i$ )	
	Minimum cash ( $R_{\text{min}} = \rho_{\text{min}} A_i$ )		
Loans ( $C_i = \beta_i A_i$ )		Interbank borrowing ( $L_i$ )	
Interbank loans ( $B_i$ )		Excess equity ( $E_{\text{excess}} = \alpha_{\text{excess}} A_i$ )	Equity ( $E_i = \alpha_i A_i$ )
		Minimum equity ( $E_{\text{min}} = \alpha_{\text{min}} A_i$ )	

# The banking system

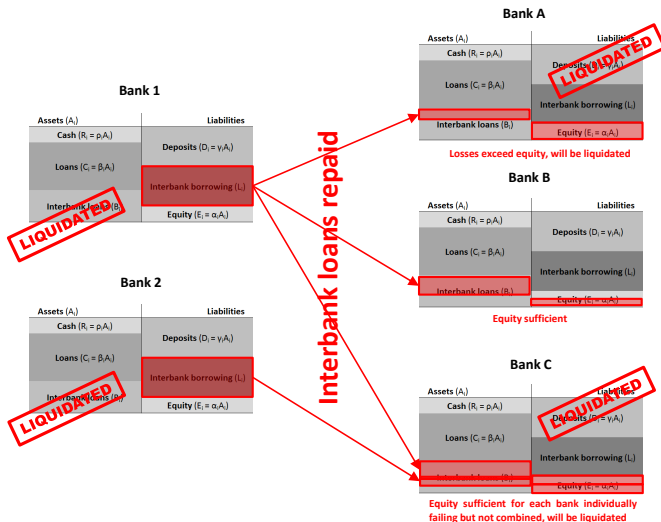
- Banks are connected via interbank loans
- Bank sizes have Powerlaw distribution
- Scale-free network of interbank loans (number of links proportional to size)



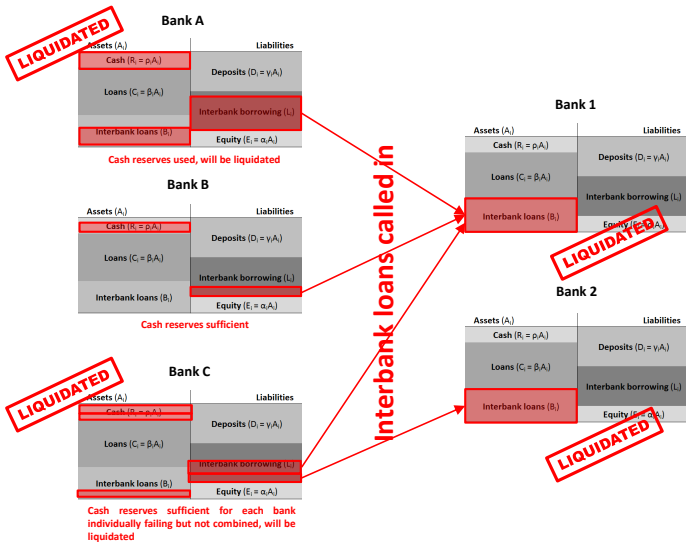
# Sample banking systems



# Contagion mechanism - default



# Contagion mechanism - failure



# Trigger mechanism

- We exogenously select one bank who we assume makes losses equal to its equity and liquidate it
- Banks selected are biggest, second biggest and one from each size decile beyond that

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# Parameters used

- Banking system:  $[12; 1,000]$  banks
- Asset value:  $[100; 100,000,000,000]$
- Tail index of size distribution:  $[1.5; 5]$
- Recovery rate of loans:  $[0; 1]$
- Fraction minimum equity:  $\alpha^{min} = [0; 0.15]$
- Fraction excess equity:  $\alpha_i^{excess} = [0; 0.1]$
- Fraction minimum liquidity:  $\rho^{min} = [0; 0.15]$
- Fraction excess liquidity:  $\rho_i^{excess} = [0; 0.1]$
- Fraction deposits:  $\gamma_i = [0; 1 - \alpha_i]$
- Fraction loans to public  $\beta_i = [0; 1]$

# Factors identified in PCA for banking systems

**TOPOLOGY** measures the interconnectedness of the interbank loan network

**LIABILITIES STRUCTURE** measures the reliance on few interbank loans to finance the assets

**TIERING** provides a measure for the degree of tiering in the network of interbank loans

**ASSET STRUCTURE** provides a measure for how little banks invest into well diversified interbank loans

**RECOVERY** is representing the recovery rate in case of bank failures

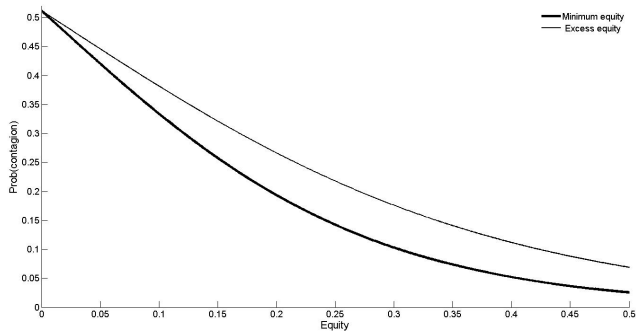
**TRIGGER** measures the size of the initially failing bank

# Effect of equity requirements on contagion

Total equity	Excess equity	Minimum equity	Prob(contagion)	Fraction of banks failing
4.00%	4.00%	0.00%	45.87%	1.45%
	0.00%	4.00%	43.85%	2.69%
6.00%	6.00%	0.00%	43.25%	1.19%
	2.00%	4.00%	41.24%	2.43%
	0.00%	6.00%	40.27%	3.05%
8.50%	8.50%	0.00%	40.03%	0.87%
	4.50%	4.00%	38.06%	2.10%
	2.50%	6.00%	37.10%	2.72%
	0.00%	8.50%	35.93%	3.50%
11.00%	11.00%	0.00%	36.89%	0.55%
	7.00%	4.00%	34.99%	1.78%
	5.00%	6.00%	34.06%	2.40%
	2.50%	8.50%	32.91%	3.17%
	0.00%	11.00%	31.81%	3.94%



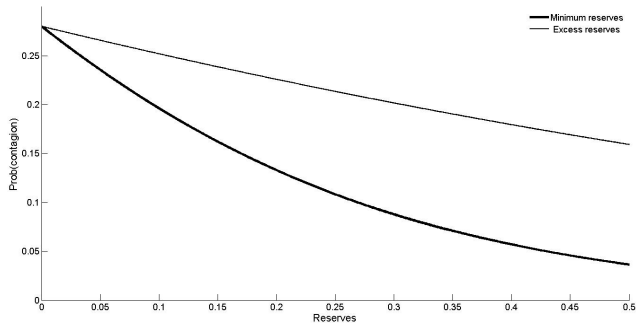
# Effect of equity requirements on contagion



# Effect of liquidity requirements on contagion

Total reserves	Excess reserves	Minimum reserves	Prob(contagion)	Fraction of banks failing
3.00%	3.00%	0.00%	27.15%	1.78%
	0.00%	3.00%	25.29%	2.57%
6.00%	6.00%	0.00%	26.31%	1.62%
	3.00%	3.00%	24.48%	2.40%
	0.00%	6.00%	22.74%	3.19%
9.00%	9.00%	0.00%	25.48%	1.45%
	6.00%	3.00%	23.69%	2.24%
	3.00%	6.00%	21.99%	3.02%
	0.00%	9.00%	20.38%	3.81%

# Effect of liquidity requirements on contagion



- Excess cash and equity is heterogeneous
- Contagion can be stopped if a bank has large buffer
- Heterogeneity can limit the extent of contagion
- Heterogeneity makes the observance of contagion more likely

# Factors identified in PCA for individual banks

**MARKET STRUCTURE** measures how large and concentrated the banking system is

**LIABILITIES STRUCTURE** measures the reliance on few interbank loans to finance the assets

**ASSET STRUCTURE** provides a measure for how little banks invest into well diversified interbank loans

**HUB** measures how closely integrated a bank is in its immediate neighborhood

**CENTRALITY** provides a measure for the importance of the bank on the interbank loan market

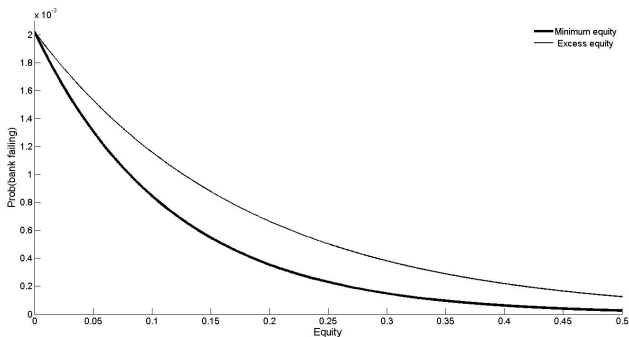
**RECOVERY** is representing the recovery rate in case of bank failures

**TRIGGER** measures the size of the initially failing bank

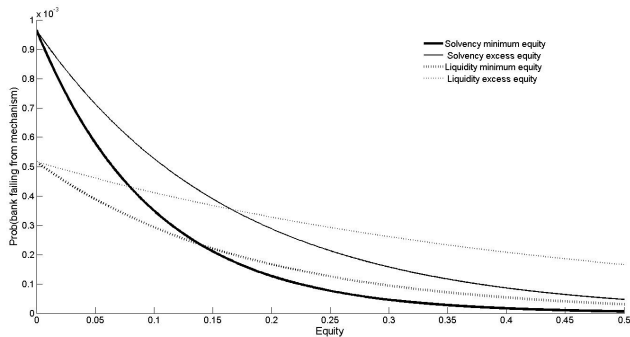
# Effect of equity requirements on individual failures

Total equity	Excess equity	Minimum equity	Prob(failing)	Prob(Solvency)	Prob(Liquidity)
4.00%	4.00%	0.00%	0.1620%	0.1081%	0.0471%
	0.00%	4.00%	0.1429%	0.0917%	0.0411%
6.00%	6.00%	0.00%	0.1449%	0.0957%	0.0450%
	2.00%	4.00%	0.1278%	0.0812%	0.0393%
	0.00%	6.00%	0.1201%	0.0748%	0.0367%
8.50%	8.50%	0.00%	0.1261%	0.0823%	0.0425%
	4.50%	4.00%	0.1112%	0.0698%	0.0371%
	2.50%	6.00%	0.1045%	0.0643%	0.0347%
	0.00%	8.50%	0.0966%	0.0581%	0.0319%
11.00%	11.00%	0.00%	0.1098%	0.0708%	0.0402%
	7.00%	4.00%	0.0968%	0.0601%	0.0351%
	5.00%	6.00%	0.0909%	0.0553%	0.0328%
	2.50%	8.50%	0.0840%	0.0499%	0.0301%
	0.00%	11.00%	0.0777%	0.0451%	0.0277%

# Effect of equity requirements on individual failure



# Effect of equity requirements on individual failure by different contagion mechanisms





# Effect of liquidity requirements on individual failures

Total reserves	Excess reserves	Minimum reserves	Prob(failing)	Prob(Solvency)	Prob(Liquidity)
3.00%	3.00%	0.00%	0.0454%	0.0218%	0.0464%
	0.00%	3.00%	0.0496%	0.0229%	0.0500%
6.00%	6.00%	0.00%	0.0445%	0.0218%	0.0424%
	3.00%	3.00%	0.0486%	0.0230%	0.0456%
	0.00%	6.00%	0.0531%	0.0242%	0.0491%
9.00%	9.00%	0.00%	0.0436%	0.0219%	0.0387%
	6.00%	3.00%	0.0477%	0.0231%	0.0417%
	3.00%	6.00%	0.0521%	0.0243%	0.0449%
	0.00%	9.00%	0.0569%	0.0256%	0.0483%

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# Main findings

- Impact of higher minimum capital and liquidity requirements is small
- Higher common minimum requirements increases the extent of contagion
- Excess capital and liquidity has a similar impact to minimum standards
- "One-size-fits-all" capital/reserve requirements may not be not appropriate and can be tailored

# Future work

- What criteria should be used to tailor capital and liquidity requirements?
- Evaluation of actual banking systems
- Optimal bank responses to an unfolding crisis