Banking system capitalization and systemic liquidity crises: Looking beyond the aggregate

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[a] The views expressed are not necessarily those of the Bank of England.

Motivation

- More capitalized banks are sounder:
  - Higher cushion against losses
  - Greater incentives for due diligence in risk management
- Corollary: Supervisors typically assess the system's robustness by examining aggregate capital levels...
- But is this extrapolation straightforward?

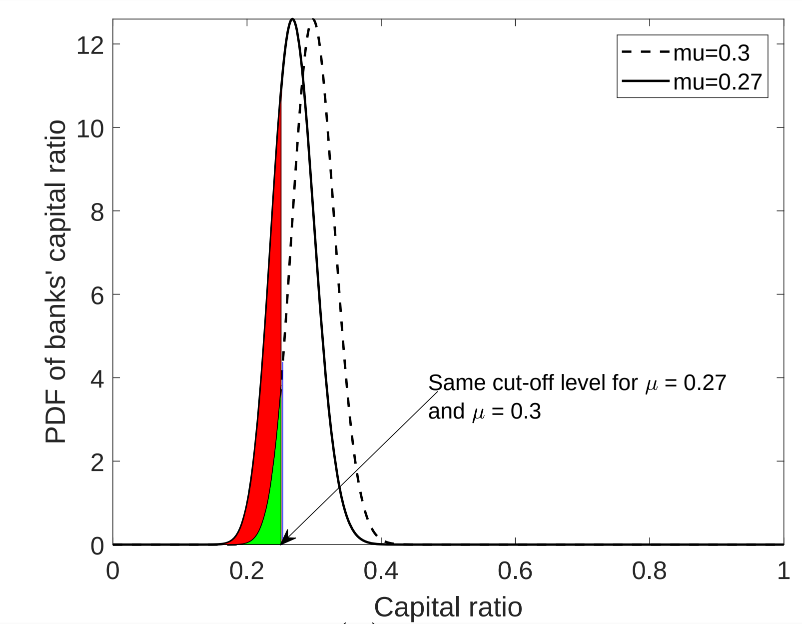
Research Question

Does the distribution of capital in the system affect the robustness of the system?

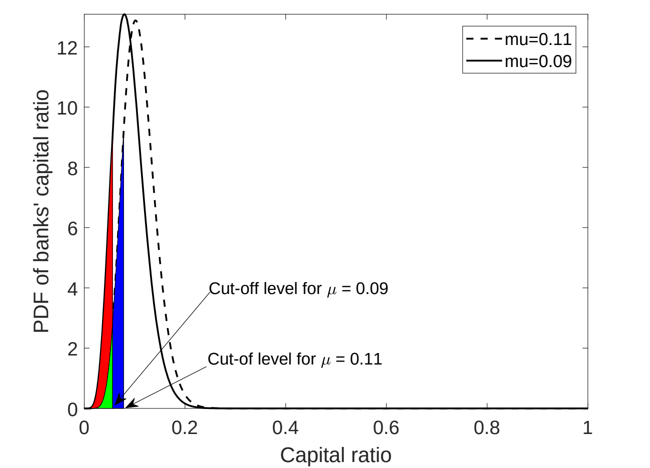
- Robustness of the system: Proportion of banks that fail after a liquidity shock.
- Focus on liquidity risk.

Results

- There is an inverted-U shaped relationship between the aggregate capital of the banking sector and its robustness to liquidity shocks:
  - For *low levels* of aggregate capital, a distribution shift (in FOSD sense) *increases* the proportion of banks that fail after a liquidity shock.
  - For *high levels* of aggregate capital, a distribution shift (in FOSD sense) *decreases* the proportion of banks that fail after a liquidity shock.


12
10
8
6
4
2
0
PDF of banks' capital ratio
0
0.2
0.4
0.6
0.8
1
Capital ratio
mu=0.3
mu=0.27
Same cut-off level for μ = 0.27
and μ = 0.3

(b) Panel B



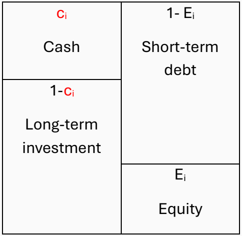
The cut-off level for liquid/non-liquid banks change due to changes in the price of the assets.

Contribution

- This paper is related to a large literature on the effects of bank capital on banks' resilience and risk-taking.
- Key related literature:
  - Capital and Liquidity risk
    - Positive approach: Castiglionesi, Feriozzi and Pelizzon (2014); Song and Thakor (2023).
    - Normative approach: Carletti, Goldstein, and Leonello (2020); Kara and Ozsoy (2020); Kashyap, Tsomocos, and Vardoulakis (2024).
  - Banks' liquidity hoarding: Acharya, Shin, and Yorulmazer (2011a); Malherbe (2014); Heider, Hoerova, and Holthausen (2015); Acharya, Iyer, and Sundaram (2015).
  - Optimal design of bank liquidity requirement: Calomiris, Castells, Heider, and Hoerova (2024); Walther (2016); Santos and Suarez (2019).

The model

- Time: 3 dates $t = 0, 1, 2$
- A continuum of banks that differ in internal capital $E_i \in (0, 1)$
- E_i is observed and follows a distribution $F_h(.)$
- The size of the bank's balance sheet is normalized to 1
- At date 0, bank's balance sheet:



Bank Funding and Investment Opportunities

- Bank i is funded at date 0 with:
  - Equity of amount E_i.
  - Short-term debt of amount $1 - E_i$, payable at date $t = 1$. Face value of short-term debt is denoted by D_i^1.
- Two investment opportunities:
  - Cash (liquid assets): Return equal to 1
  - Long-term investment: Risky return

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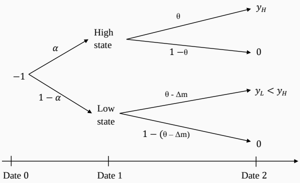

Timeline

Date 0

Each bank i chooses its liquid asset holdings c_i and its long-term asset holdings $1 - c_i$.

Date 1

- Quality of long-term assets is observed
- Banks **repay their debt** by using their *cash* holdings, (possibly) *issuing new debt* or *selling their long-term assets*.
- If a bank cannot raise sufficient liquidity, it is liquidated.

Moral Hazard

Date 2

- The projects' cash flows are realized.
- Payments are settled.

Parametric assumptions

- In the event of bad news at date 1, investors will only lend to a bank if they are assured that the bank will exert monitoring effort:

$$\theta y_L \geq 1 \geq (\theta - \Delta) y_L + B$$

- The liquidity raised against one unit of the long-term asset in case of bad news is less than that from one unit of liquid assets:

$$\theta(y_L - B/\Delta) \leq 1$$

Basic Model: Remarks

- Liquidity shock
  - No uncertainty about the debt repayment but uncertainty about the banks' funding capacity at date 1:
    - Good news (High state) at date 1, borrowing is unconstrained $\Rightarrow$ no issues in rolling over short-term debt.
    - Bad news (Low state) at date 1, funding capacity is restricted $\Rightarrow$ rolling-over debt is problematic.
  - The scenario is analogous to what happened in the 2007-2009 crisis.

Determinants of bank liquidity: Funding Liquidity

- Liquidity needs are $D_i^1 - c_i$
- If high state is realized $\Rightarrow$ no problem in rolling over short-term debt.
- If low state is realized, the ICC is as follows:

$$D_i^2 \leq \left(y_L - \frac{B}{\Delta}\right)(1 - c_i)$$

  - The maximum borrowing capacity per unit of long-term asset is:

$$\rho^* = \theta\left(y_L - \frac{B}{\Delta}\right)$$

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- Liquidity needs per unit of long-term assets

$$\rho_i = \frac{D_i^1 - c_i}{1 - c_i}$$

Determinants of bank liquidity: Funding Liquidity (Continued)

Lemma
At $t = 1$, for any bank i:

(i) If $\rho_i \leq \rho^*$, the bank can raise sufficient funding through new debt issuance to repay its short-term debt in both states of nature, without needing to sell any assets.

(ii) If $\rho_i > \rho^*$, in the event of bad news, the bank cannot raise enough liquidity through new debt issuance and must sell part of its long-term assets to repay its short-term debt.

Determinants of bank liquidity: Asset sales

- **Sellers**: banks with $\rho_i > \rho^*$
  - β_i: fraction of long-term assets sold by bank i.
- **Buyers:** banks with $\rho_i \leq \rho^*$
  - γ_i : volume of long-term assets bought by bank i per unit of long-term assets it has.
- p: per unit price of long-term asset.

Determinants of bank liquidity: Asset sales (Continued)

- Individual banks' supply:

$$\beta_i(1-c_i)p + (1-c_i)(1-\beta_i)\rho^* \geq D_i^1 - c_i$$

which is equivalent to

$$\beta_i = \min\left(1, \frac{\rho_i - \rho^*}{p - \rho^*}\right)$$

- Individual banks' demand:
  - If $p > \theta y_L$: $\gamma_i = 0$.
  - If $\rho^* < p < \theta y_L$, γ_i is determined as follows:

  $$(1 - c_i + \gamma_i)\,\rho^* - (D_i - c_i) = \gamma_i(1-c_i)p$$

  which implies

  $$\gamma_i = (1-c_i)\,\frac{\rho^* - \rho_i}{p - \rho^*}$$

  - If $p = \theta y_L$, γ_i any value btw 0 and $(1-c_i)\,\frac{\rho^*-\rho_i}{p-\rho^*}$
  - If $p = \rho^*$, γ_i is ∞

Banks' optimal liquidity holdings

- Banks' choose c_i in order to maximize their profit:

$$\underset{c_i \in [0,1]}{\text{Max}}\, \Pi_i = (1-c_i)NPV + (1-\alpha)(1-c_i)\gamma_i(\theta y_L - p)\mathbf{1}_{\rho_i \leq \rho^*} - (1-\alpha)(1-c_i)\beta_i(\theta y_L - p)\mathbf{1}_{\rho_i > \rho^*}$$

subject to

- Depositors' participation constraint:

$$\alpha D_1^i + (1-\alpha) D_1^i \mathbf{1}_{\rho_i \leq \rho^*} + (1-\alpha) min \left[D_1^i, (1-c_i)\beta_i p + (1-c_i)(1-\beta_i)\rho^* + c_i \right] \mathbf{1}_{\rho_i > \rho^*} = 1 - E_i$$

- Where p is the equilibrium price.

Competitive equilibrium

Definition of the ex-ante competitive equilibrium: A competitive equilibrium is: (1) a set of banks' liquidity holdings $\{c_i^*\}_{i\in[0,1]}$; and (2) the equilibrium price p^e of the long-term assets at date 1, following the revelation of bad news such that:

(1) c_i^* is the optimal amount of liquid assets that each bank i holds, given p^e.

(2) p^e is the equilibrium price induced by the choices $\{c_i^*\}_{i\in[0,1]}$.

Competitive equilibrium: Result 1

Proposition
Only a competitive equilibrium where $p^e \leq \hat{\rho} < \theta y_L$ *can exist.*

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Lemma (A)

If $p^e = \hat{\rho}$, there exists a cutoff capital ratio $\hat{E} = 1 - \hat{\rho}$ such that:

- *Banks with a capital ratio lower than $\hat{E}$ hold zero liquidity and will be closed at date 1 following the realization of the liquidity shock.*
- *Banks with a capital ratio greater than or equal to $\hat{E}$ are indifferent to any liquidity holdings between max $\left(\frac{1-\rho^*-E_i}{1-\rho^*}, 0\right)$ and 1 and will survive the shock.*

Lemma (B)

If $p^e < \hat{\rho}$, there exists a cutoff capital ratio $\bar{E}$ such that:

- *Banks with a capital ratio lower than $\bar{E}$ hold zero liquidity and will be closed at date 1 following the realization of the liquidity shock.*
- *Banks with a capital ratio greater than or equal to $\bar{E}$ invest all their funds in liquid assets, surviving the liquidity shock.*

The cutoff level $\bar{E}$ and the equilibrium price p^e are determined by the following equations:

$$\frac{\overline{E}}{p - \rho^*} + 1 = \frac{NPV}{(1-\alpha)(\theta y_L - p)} \tag{1}$$

$$\int_{\overline{E}}^{1} Ef(E,h)dE = p^e \int_0^{\overline{E}} f(E,h)dE \tag{2}$$

Competitive equilibrium: Result 2

- The threshold $\bar{E}$ increases with the equilibrium price p^e.

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- The threshold $\bar{E}$ increases with the equilibrium price p^e.
- There exists a unique value for the parameter $\hat{h}$, such that $p(E(\hat{h}), \hat{h}) = \hat{\rho}$
  - If $h \geq \hat{h}$, the equilibrium corresponds to the one described in Lemma A.
  - If $h < \hat{h}$, the equilibrium corresponds to the one described in Lemma B.

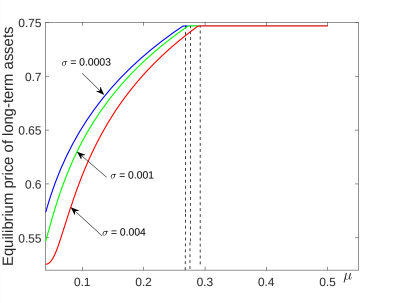
Comparative statics

$$\frac{dp^e(\hat{E}^e(h),h)}{dh} = \underbrace{\overbrace{\frac{\partial p^e(\hat{E}^e(h),h)}{\partial h}}^{\geq 0}}_{\text{Effect of precautionary motive}} + \underbrace{\overbrace{\frac{\partial p^e(\hat{E}^e(h),h)}{\partial \hat{E}^e}}^{<0}\overbrace{\frac{\partial \hat{E}^e(h)}{\partial h}}^{\geq 0}}_{\text{Effect of speculative motive}} \tag{3}$$

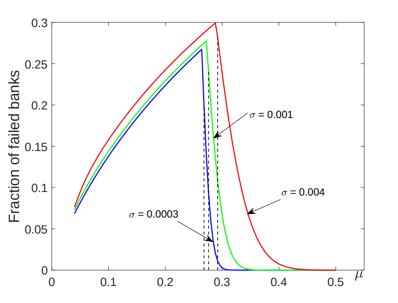
and

$$\frac{dF(\hat{E}^e,h)}{dh} = \underbrace{\overbrace{\frac{\partial F(\hat{E}^e(h),h)}{\partial h}}^{\leq 0}}_{\text{Effect of precautionary motive}} + \underbrace{\overbrace{\frac{\partial F(\hat{E}^e(h),h)}{\partial \hat{E}^e}}^{\geq 0}\overbrace{\frac{\partial \hat{E}^e(h)}{\partial h}}^{\geq 0}}_{\text{Effect of speculative motive}} \tag{4}$$

ggregate capital ratio: Figures 5(a) and 5(b) illustrates, respectively, the equilib-
ım price and the fraction of failed banks for different values of μ.



(a) Equilibrium price for different values of μ



(b) Fraction of failed banks for different values of μ

Figure 5: Impact of the aggregate capital ratio on the competitive equilibrium

Concluding Remarks

- This paper develops a model of banks' liquidity management, exploring the relationship between capital distribution in the banking system and its resilience to systemic liquidity shocks.
- Our setting endogenizes the amount of liquidity that banks hold ex-ante to protect themselves from liquidity shocks and the subsequent extent of deleveraging through asset sales.
- We show that incentives to hold liquidity of an individual bank not only depends on its own level of capital also depend on the distribution of capital in the whole system.
- We identify two opposite effects of the system's aggregate capital.
- These effects lead to an inverted-U shaped relationship between the aggregate capital of the banking sector and its vulnerability.
- **Next step:** To endogenize the capital structure.

Thank you very much for your attention.

US banks' distribution

Does the distribution of capital in the system affect the robustness of the system?