Risk Taking, Banking Crises, and Macroprudential Monetary Policy

Mai Hakamada

University of California, Santa Cruz

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Motivation

- The Global Financial Crisis was preceded by financial intermediaries' risk taking:
  - Accommodative financial condition (low interest rates)
  - Elevated risk taking on assets by financial intermediaries (search for yield)

$\longrightarrow$ Vulnerability to financial systems figure

- Policy question:
  - Can a central bank's monetary policy increase welfare by taking into account the financial intermediaries' risk-taking incentives?
    - Leaning Against the Wind monetary policy:
      set interest rates higher during financial booms to moderate risk taking

- Why does this research focus on monetary policy?
  - Practical limitations to deploying time-varying macroprudential financial tools
    1. Legal limitations 2. Regulatory arbitrages
    3. No activation records (e.g. US) 4. Unclear effects on the asset risk choice

- This research:
  - Evaluate the welfare impact of macroprudential monetary policy in a New Keynesian model with endogenous bank risk taking on assets and bank runs

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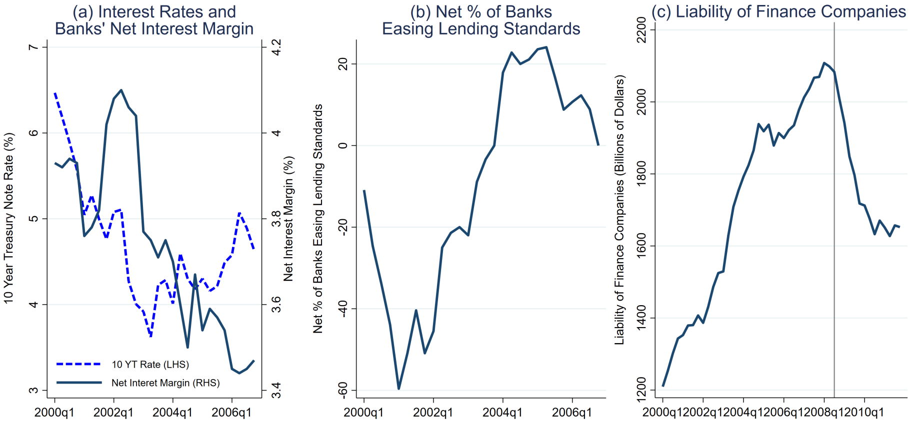

Source: Board of Governors of the Federal Reserve System (US): Senior Loan Officer Opinion Survey on Bank Lending Practices, Z.1 Financial Accounts of the United States (L.128 finance companies)

Back

This Research

- Provides new empirical evidence of the effect of pre-crisis bank risk taking on runs by creditors during the crisis (Bank-level balance sheet data in the US)
- Develops a New-Keynesian model with bank-lending channel of monetary policy (À la Gertler and Karadi (2011) model) with
  1. Banks' asset risk taking is endogenous
  2. Bank runs are endogenous

  → Employs a global solution method (time-iteration) to deal with non-linearity
- Provides a quantitative analysis by calibrating the model with financial and real data
- Analyzes the welfare impact of the Leaning Against the Wind Augmented Taylor rule:

$$\text{Interest Rates} = f(\text{Inflation}, \text{Banks' Net Worth})$$

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Key Mechanisms of the Model

1. Endogenous bank risk taking (monitoring):
   - Banks' monitoring determines loans' risk
   - Search for yield: Lower spreads $\longrightarrow$ less monitoring $\longrightarrow$ higher risk on loans
2. Endogenous bank runs:
   - The likelihood of a run depends on banks' balance sheet and risk choice
   - Higher loan risk $\longrightarrow$ more defaults on loans $\longrightarrow$ higher probability of bank run

   $\Rightarrow$ Lower spreads $\longrightarrow$ higher loan risk $\longrightarrow$ more vulnerable to run
3. Bank lending channel of monetary policy:

   À la Gertler and Karadi (2011, 2013), Bernanke, Gertler, and Gilchrist (1999)
   - Bank lending channel: credit spreads are a positive function of interest rates
   - Higher rates $\longrightarrow$ lower credit supply $\longrightarrow$ higher credit spreads

New Results and Contributions

1. Empirical Results
   - Exploits bank level variations (pre crisis: 2004 to 2007, crisis: 2008 to 2010)
     - Banks with higher risk on assets → higher probability of withdrawals
     - Impacts of asset risk: Quantitatively larger than the impact of leverage
2. Model and Quantitative Results
   - Endogenous bank risk taking:

     increases the likelihood of observing a bank run in the great recession by 35%.
   - Welfare evaluation of macroprudential monetary policy:
     - Augmented Taylor rule that sets higher interest rates during financial booms:
       Higher welfare: Welfare gain for decreasing probability of financial panic outweighs the cost
       → 25bps (annual) ↑ during the boom → 5% higher welfare

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Related Literature

- Empirical Literature of Monetary Policy and Bank Risk Taking
  - [Maddaloni and Luis Peydro (2011), Jimenez, Ongena, Luis Peydro and Saurina (2014), Dell'Ariccia, Laeven and Suarez (2017), Paligorova and Santos (2017)]
- Macro Literature of Financial Panic
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Outline

Empirical Test for Endogeneous Risk Taking and Run

- **Purpose:** Investigates the effect of bank risk taking during the boom preceding *the Global Financial Crisis* on withdrawal in wholesale funding markets during the financial crisis
- **Data:** Reports of Conditions and Income (“Call Reports") filed by banks in accordance with the Federal Reserve System, FDIC, and OCC regulations. (Commercial banks : forms FFIEC 031 and 041)
  - **Balance sheet variables:** Assets, risk-weighted assets, equity, wholesale funding, cash, loans and securities by duration, and time deposits by duration
  - **Sample periods:** Pre-crisis: 2003Q1-2007Q4, Crisis: 2008Q1-2010Q4
- **Identification:**
  1. Bank level variation:
     Control for observable bank level characteristics that are correlated with asset risk
  2. Different timing of dependent and independent variables:
     Enable to observe effects of risk during boom on the crisis, and eliminate the reverse causality
- **Robustness:**
  1. Discrete and continuous measure of run (withdrawal and inflow)
  2. Adjacent different time average
  3. Panel regression
  4. Regression with additional controls:
     Other asset risks (maturity mismatch and liquidity risk)
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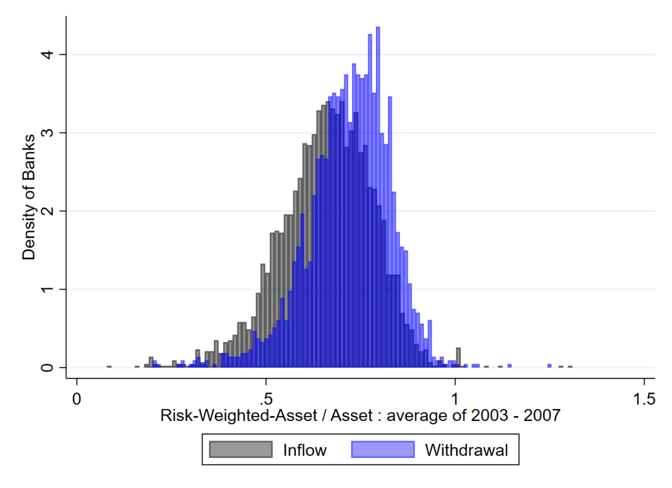
Empirical Test for Endogeneous Risk Taking and Run

Distribution of withdrawal / inflow banks – wholesale funding

- Definition: ΔWholesale Funding $= \Delta\left(\frac{\text{Liability-Deposits}}{\text{Assets}}\right) < 0$: withdrawal, Asset Risk $= \left(\frac{\text{Risk-Weighted Assets}}{\text{Assets}}\right)$
- Timing: Wholesale Funding: 2008Q1-2010Q4, Asset Risk: 2003Q1-2007Q4



Summary of Empirical Results

Effects of Asset Risk Increases on Wholesale Withdrawal

- Definition: $I^{\text{Wholesale Funding}} = -1$ if deposit has withdraw, 0 if deposit has inflow, Leverage = $\left(\frac{\text{Assets}}{\text{Equity}}\right)$
- Timing: Wholesale Funding: 2008Q1-2010Q4, Asset Risk & Leverage: 2003Q1-2007Q4
- Specification: **Linear Probability Model**

$$I_i^{\text{Wholesale Funding}} = \beta_0 + \beta_1 \log(\overline{\textbf{Asset Risk}})_i + \beta_2 \log(\overline{\text{Leverage}})_i + \beta_3 \log(\overline{\text{Asset}})_i + \epsilon_i$$

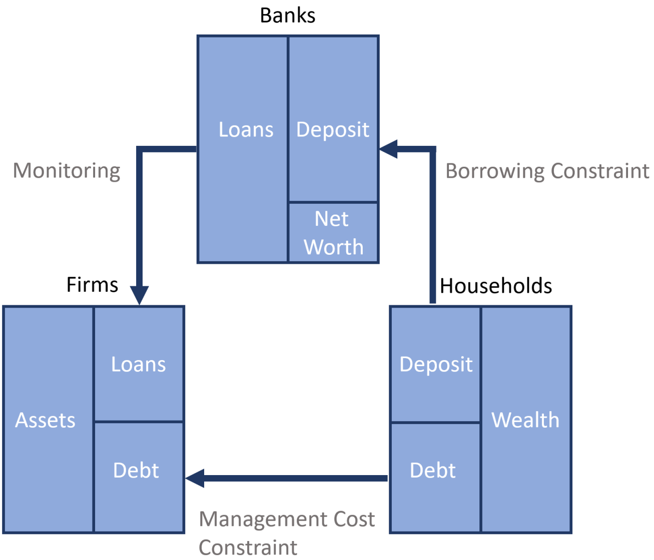
	(a) Total Sample		(b) Community Bank		(c) Non-Community Bank	
	1	2	3	4	5	6
$\log(\overline{\text{Asset Risk}})$	**-0.493***	**-0.415***	**-0.461***	**-0.386***	**-0.340***	**-0.344***
	(0.120)	(0.125)	(0.120)	(0.125)	(0.118)	(0.123)
$\log(\overline{\text{Leverage}})$		-0.175***		-0.170***		-0.062
		(0.028)		(0.029)		(0.223)
$\log(\overline{\text{Asset}})$	-0.098***	-0.093***	-0.105***	-0.010***	-0.028	-0.028
	(0.005)	(0.005)	(0.005)	(0.005)	(0.036)	(0.036)
Constant	0.679***	1.042***	0.760***	1.096***	-0.301	-0.149
	(0.059)	(0.084)	(0.069)	(0.090)	(0.643)	(0.806)
Observations	5,718	5,718	5,654	5,654	64	64
R-squared	0.106	0.114	0.098	0.105	0.086	0.088

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Descriptive Statistics Continuous Measure

Model Environment

- Agents:
  - Households:
    - Deposit to banks or directly finance firms, and supply labor to intermediate firm
  - Banks:
    - Supply loans to intermediate firms by raising deposits from households and decide the monitoring intensity
  - Intermediate firms:
    - Finance themselves with bank loan or household direct finance and produce intermediate goods
  - Capital goods producers:
    - Produce capital goods
  - Retail firms:
    - Set retail goods prices based on Rotemberg pricing
  - Central Bank:
    - Set nominal interest rates
- States:
  - Endogenous states: capital and banks' net worth


Banks
Loans
Deposit
Net Worth
Monitoring
Borrowing Constraint
Firms
Households
Assets
Loans
Debt
Deposit
Debt
Wealth
Management Cost Constraint

Bank

- Bank raises funds from household deposits at rate R_t^D, lend to intermediate goods firm at rate R_t^K
- The bank balance sheet is given by

$$Q_t s_t^B = n_t + d_t \tag{1}$$

- Monitoring: Banks choose monitoring intensity. Monitoring increases the probability of return R_t^K but entails quadratic cost $c(m_t)$.
  - Intermediate goods firms' projects returns are stochastic

$$\tilde{R}_t^K = \begin{cases} R_t^K & \text{with probability } (p^m + m_{t-1}) \\ 0 & \text{with probability } 1 - (p^m + m_{t-1}) \end{cases} \tag{2}$$

Bank Balance Sheet – No Bank Run Case

- When the project failed, banks do not pay the gross deposit rate to households.

$$E_t n_{t+1} = (p^m + m_t) \overbrace{\left(E_t R^K_{t+1} Q_t s^B_t - E_t R^D_{t+1} d_t\right)}^{\text{Expected Profits} \mid \text{Success in the Project}} + (1 - (p^m + m_t)) \underbrace{\left(0 \cdot Q_t s^B_t - 0 \cdot d_t\right)}_{\text{Expected Profits} \mid \text{Failure}} - c(m_t) Q_t s^B_t$$

  - → The cost of default is transferred to households (Risky deposits).
- Moral hazard: Monitoring is not contractable
  - → Banks choose monitoring that maximizes their own continuation value
- The aggregate law of motion of net worth is,

$$N_t = \sigma \underbrace{\left[\frac{[(p^m + m_{t-1})(R^K_t - R^D_t) - c(m_{t-1})] Q_{t-1} S^B_{t-1}}{N_{t-1}} + m_{t-1} R_t \right]}_{\text{Return on Equity: } R^N_t} N_{t-1} + X S^B_{t-1} \tag{3}$$

Bank Balance Sheet – No Bank Run Case

- Bank optimization problem is,

$$V_t = \max_{m_t, s_t^B} E_t \sum_{i=1}^{\infty} (1-\sigma)\sigma^{i-1} \Lambda_{t,t+i} n_{t+i} \quad (4)$$

$$\text{s.t. } \phi \geq \frac{Q_t s_t^B}{n_t} \quad (5)$$

and balance sheet equation, and law of motion of net worth.

- Optimal condition for monitoring m_t,

$$\underbrace{\gamma m_t}_{\text{Marginal Cost}} = \underbrace{E_t \tilde{\Lambda}_{t,t+1} (R_{t+1}^K - \nu R_{t+1}^D)}_{\text{Marginal Benefit}}, \quad (6)$$

where $\nu = \left(1 - \frac{1}{\phi}\right)$

$\rightarrow$ Lower spreads induce lower monitoring intensity

Bank Run: Self-fulfilling Rollover Crises

- $\boxed{\text{Bank Run}}$
  - At the beginning of period t, households decide whether to roll over their deposits or run (Similar to Gertler, Kiyotaki, and Prestipino (2020) and Cole and Kehoe (2000)) based on banks' balance sheet and risk choice.
  - If a bank run is declared, banks have to sell the loans to less productive households
    - Return on loans those are held by household:

$$R_t^{K,H} = \frac{R_t^{K,B}}{1 + \underbrace{\frac{f'(S_{t-1}^H)}{Q_t u'(C_{t-1})}}_{\text{Management cost}}} \tag{7}$$

  $\rightarrow$ fire-sale (liquidation) price on loans
  - The net worth in banking system is wiped out $\rightarrow$ a crucial credit disruption

Figure

Bank Run

- Run/Insolvency Region
  - Banking sector to be insolvent at $t+1$ iff:

$$\underbrace{(p^m + m_t) R^K_{t+1} Q_t S^B_t}_{\text{Asset Value}} < \underbrace{R^D_{t+1} D_t}_{\text{Outstanding Liability}} \tag{8}$$

$\rightarrow$ Withdrawal with probability 1.

  - Even if banks are solvent, the sunspot run can occur at $t+1$ iff

$$\underbrace{(p^m + m_t) \overbrace{R^{K*}_{t+1}}^{\text{Liquidation price}} Q_t S^B_t}_{\text{Asset Liquidation (Fire-sale) Value}} < R^D_{t+1} D_t < \underbrace{(p^m + m_t) R^K_{t+1} Q_t S^B_t}_{\text{Asset Value}} \tag{9}$$

and sunspot indicator $\upsilon = 1$ (10)

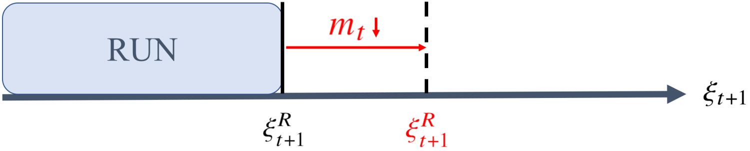
$\rightarrow$ Withdrawal with probability κ.

Liquidation price Multiplicity

Bank-Run Vulnerability

- ξ^R_{t+1} is threshold capital quality shock value below which a run equilibrium exists

$$R^{K,R*}_{t+1}(\xi^R_{t+1}) = \frac{1}{p^m + m_t} R^D_{t+1} \cdot \left(1 - \frac{N_t}{Q_t S^B_t}\right)$$



- Bank-run probability is a function of risk taking (monitoring)
- Higher risk (lower monitoring m_t)$\longrightarrow$ more vulnerable to run

Default Probability Deposit Pricing

- Monetary policy rule

$$R_t^N = \frac{1}{\beta}(\pi_t)^{\kappa_\pi}\big(\underbrace{\mathrm{n}_t}_{\text{Pro-cyclical}}\big)^{\kappa_n}$$

→ Higher interest rates reduces the asset price of capital and banks' net worth

- Credit supply curve

$$Q_t s_t^B = \phi n_t \tag{11}$$

→ Higher rates and lower net worth curtails the credit supply

→ Unwinds the shrinkage of credit spread during financial booms

→ Risk taking ("search for yield") is also moderated

→ Less vulnerability to bank runs

Analytical Findings

1. Bank risk taking (monitoring):
   - Search for yield: Lower spreads $\longrightarrow$ less monitoring $\longrightarrow$ higher risk on loans
2. Bank runs:
   - Higher risk $\longrightarrow$ more defaults on loans $\longrightarrow$ higher probability of bank run
3. Bank lending channel of monetary policy:
   - Higher rates $\longrightarrow$ lower credit supply $\longrightarrow$ higher credit spreads

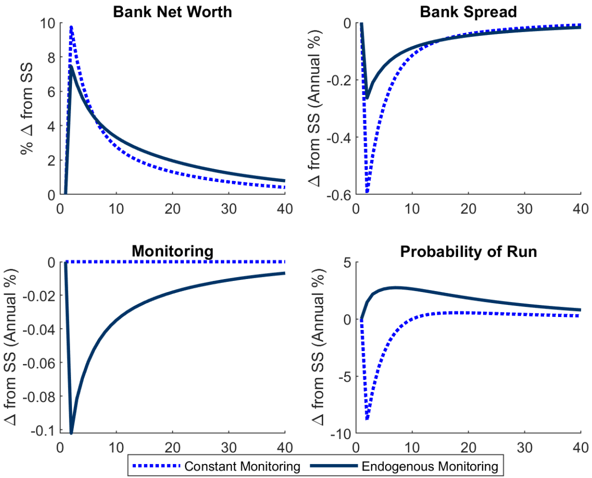
Households Firms

Solution Method and Calibration

- Global solution method:
  - Major non-linearity: run realization
  - Time-iteration with linear-interpolation
- Key Parameters

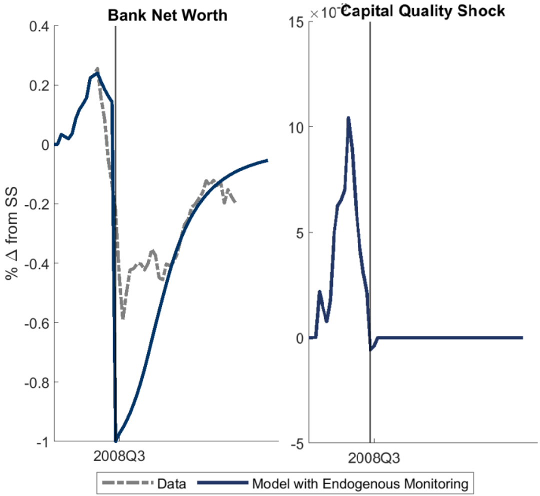
Parameter	Value	Description	Target
		Financial Sector	
θ	0.21	HH Intermediation Costs	$ER^K - R = 2\%$ Annual
X	0.14%	New Banker Endowment	Investment Drop in crisis = 45%
σ	0.95	Banker Survival Rate	Average Leverage = 10
κ	0.3	Sunspot Probability	Run Probability = 4% Annual
p^m	0.99	Fundamental monitoring	Firms' failure probabilities
γ	1	Monitoring cost coefficient	Lending Standard Increase in crisis
		Households and Firms	
β	0.99	Discount Rate	Risk Free Rate
γ^r	2	Degree of Risk Aversion	Literature (e.g. Gertler et al. 2020)
φ	0.5	Inverse Frisch Elasticity	Literature (e.g. Gertler and Karadi 2011)
ε	11	Elasticity of Substitution across Goods	Markup 10%
α	0.33	Capital Share	Literature (e.g. Gertler and Karadi 2011)
δ	0.25	Capital Depreciation	Literature (e.g. Gertler and Karadi 2011)
η	0.25	Capital Price Elasticity to Investment	Literature (e.g. Gertler et al. 2020)
a	0.475	Investment Technology	$Q^{ss} = 1$
b	-0.50%	Investment Technology	$\Gamma(I^{ss}) = I^{ss}$
ρ^{adj}	600	Price Adjustment Costs	Price Elasticity 0.018
		Government	
G	0.45	Government Expenditure	$\frac{G}{Y} = 0.2$
κ_π	1.5	Coefficient for Inflation	Literature (e.g. Gertler and Karadi 2011)

Figure: Positive Capital Quality Shock



Boom and Bank Run Experiment

Comparison with Data

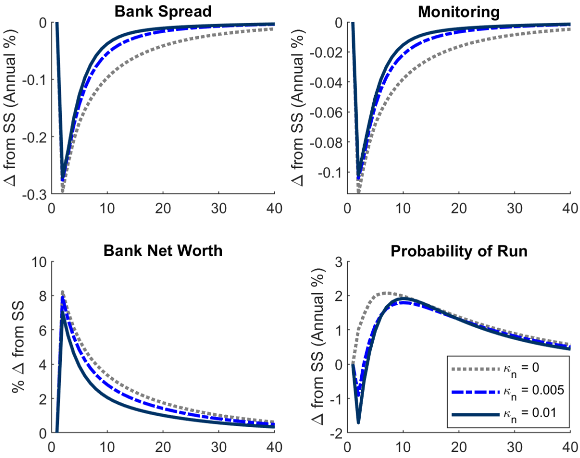


Minimum Shock Size	Constant Monitoring	Endogenous Monitoring
2008Q3	**-0.54%**	**-0.01%**

Source: XLF (Financial Select Sector SPDR ETF), SLOOS (Federal Reserve Board), CBO

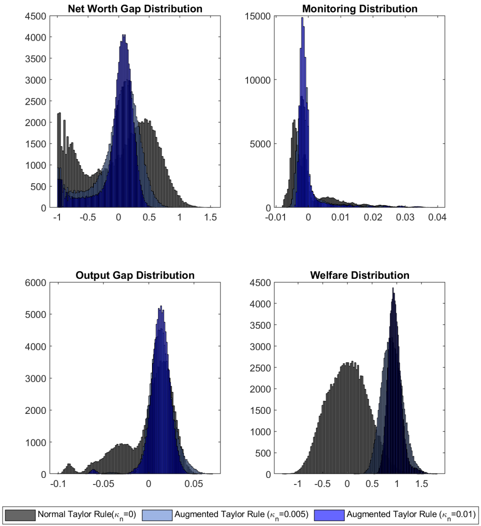
- Monetary policy rule

$$R_t^N = \frac{1}{\beta}(\pi_t)^{\kappa_\pi}(\mathrm{n}_t)^{\kappa_n}$$



Unconditional Welfare

Distribution of different shock realization



Optimal Rule

Conclusion

1. Empirical Results
   - Exploits bank level variations
     - Banks with higher risk on assets $\longrightarrow$ higher probability of withdrawals
     - Impacts of asset risk: Quantitatively larger the impact of leverage
2. Model and Quantitative Results
   - Endogenous bank risk taking:

     increases the likelihood of observing a bank run in the great recession by 35%.
   - Welfare evaluation of macroprudential monetary policy:
     - Augmented Taylor rule that sets higher interest rates during financial booms: increases welfare of the economy
       - $\longrightarrow$ 25bps (annual) $\uparrow$ during the boom $\longrightarrow$ 5% higher welfare

Appendix

Empirical Test for Endogenous Risk Taking and Bank Run

Summary Statistics

Total Sample					
Variable	Obs	Mean	Std. Dev.	Min	Max
log(Asset)	211,037	11.714	1.333	6.908	21.293
Risk-Weighted Assets	211,037	0.690	0.144	0.008	3.567
Leverage	211,037	10.034	3.109	1	241.611
Mismatch	209,434	2.803098	2.078	-3.875	22.375
Illiquidity	211,037	.9503582	.0542	0	1
Wholesale	211,037	0.719	1.029	-0.002	71.361

Small Community Banks					
Variable	Obs	Mean	Std. Dev.	Min	Max
log(Asset)	198,714	11.503	1.012	6.908	13.815
Risk-Weighted Assets	198,714	0.686	0.142	0.008	3.567
Leverage	198,714	9.980	3.098	1	241.611
Mismatch	197,270	2.765	2.033	-3.875	22.375
Illiquidity	198,714	0.950	.054	0	1
Wholesale	198,714	0.627	0.823	-0.002	71.361

Large Banks					
Variable	Obs	Mean	Std. Dev.	Min	Max
log(Asset)	12,323	15.108	1.291	13.816	21.30
Risk-Weighted Assets	12,323	0.754	0.167	0.055	3.083
Leverage	12,323	10.895	3.157	1.254	54.152
Mismatch	12,164	3.417	2.632	-3.518	21.300
Illiquidity	12,323	0.961	0.048	0.044	1
Wholesale	12,323	2.196	2.211	0.017	29.851

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Total Sample

	ΔWholesale Funding	log(Assets)	Δ Risk-Weighted Assets	Δ Leverage	Δ Maturity Mismatch	Δ Illiquidity
ΔWholesale Funding	1					
log(Assets)	-0.2636	1				
Δ Risk-Weighted Assets	-0.0639	0.0476	1			
Δ Leverage	-0.0713	-0.0743	0.0324	1		
Δ Maturity Mismatch	-0.0327	0.0560	-0.1799	0.0600	1	
Δ Illiquidity	-0.0220	-0.0366	0.1933	-0.0038	0.0203	1

Small Community Banks

	ΔWholesale Funding	log(Assets)	Δ Risk-Weighted Assets	Δ Leverage	Δ Maturity Mismatch	Δ Illiquidity
ΔWholesale Funding	1					
log(Assets)	-0.1535	1				
Δ Risk-Weighted Assets	-0.0489	0.0639	1			
Δ Leverage	-0.0483	-0.0221	0.0431	1		
Δ Maturity Mismatch	-0.0127	0.0856	-0.1756	0.0593	1	
Δ Illiquidity	-0.0271	-0.0268	0.1931	-0.0005	0.0217	1

Large Banks

	ΔWholesale Funding	log(Assets)	Δ Risk-Weighted Assets	Δ Leverage	Δ Maturity Mismatch	Δ Illiquidity
ΔWholesale Funding	1					
log(Assets)	-0.2752	1				
Δ Risk-Weighted Assets	-0.1407	-0.0692	1			
Δ Leverage	-0.3581	-0.0495	-0.0469	1		
Δ Maturity Mismatch	-0.1481	-0.0107	-0.2258	0.0669	1	
Δ Illiquidity	-0.0462	-0.0353	0.2102	-0.0675	0.0012	1

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Summary of Empirical Results

Effects of Asset Risk Increases on Wholesale Withdrawal

- Timing: Wholesale Funding: 2008Q1-2010Q4, Asset Risk & Leverage: 2003Q1-2007Q4
- Specification:

$$\Delta \log(\text{Wholesale Funding})_i = \beta_0 + \beta_1 \log(\overline{\textbf{Asset Risk}})_i + \beta_2 \log(\overline{\text{Leverage}})_i + \beta_3 \Delta \log(\textbf{Asset Risk})_i + \beta_4 \Delta \log(\text{Leverage})_i + \beta_5 \log(\overline{\text{Asset}})_i + \epsilon_i$$

VARIABLES	Total Sample			
$\log(\overline{\text{Asset Risk}})$	**-0.342*****	**-0.280*****		
	(0.081)	(0.084)		
$\log(\overline{\text{Leverage}})$		-0.195***		
		(0.070)		
Δ log (Asset Risk)			-0.221**	-0.216**
			(0.104)	(0.104)
Δ log (Leverage)				-0.029
				(0.064)
$\log(\overline{\text{Asset}})$	-0.009	-0.003	-0.021**	-0.022**
	(0.0117)	(0.011)	(0.010)	(0.010)
Constant	-0.554***	-0.151	-0.247*	-0.243*
	(0.144)	(0.212)	(0.126)	(0.126)
Observations	5,515	5,515	5,515	5,515

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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