Liquidity Requirements and the Interbank Loan Market: An Experimental Investigation

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* The views expressed in this presentation are those of the authors and not necessarily those of the Federal Reserve Bank of Cleveland or the Federal Reserve System.

Liquidity Coverage Ratio (Basel 3):

- Banks required to hold liquid assets (cash, Treasuries) to meet a cash outflow over a 30-day stressed period
- In U.S., applies mainly to large banks

Motivation for Liquidity Regulations

- The financial crisis of 2007 and 2008
  - Big liquidity (and solvency) problems
  - Runs on some banks and investment banks

- Idea is that if banks hold more liquidity, runs and panics are less likely.
  - Central banks don’t want to be lenders of first resort (lender of next month resort)

Costs of Liquidity Regulations

- Liquidity regulations reduce investment because banks make less loans and hold more cash and Treasuries

- Require to hoard liquidity during panics, making the panic worse
  - During panic liquidity is scarce => banks less likely to lend liquidity because of liquidity requirement => making liquidity even more scarce.

Question Studied

- Effect of liquidity regulations on interbank market:
  - On investment decisions: We find big effect
  - On bankruptcies: We find little effect

- Use an experimental design with
  - Investment decisions and bank failures
  - An interbank market that supplies liquidity to meet withdrawals
  - Heterogeneous withdrawal shocks across banks

Literature: Interbank lending

- Models where interbank lending is a source of liquidity
  - Bhattacharya and Gale (1987) – banks hold too few reserves
  - Allen and Gale (2004) – general interbank lending model
  - Allen, Carletti, and Gale (2009)
  - Gale and Yorulmazer (2013)
    - incomplete markets, several stages.
    - Liquidity requirements reduce chance of a panic, but make panic worse if one happens.

Literature

"With capital regulation there is a large literature but little agreement on the optimal level of requirements. With liquidity regulation, we do not even know what to argue about."

Allen and Gale, 2017

Literature: Experiments

- Most of experiments are in Dimond – Dybvig environment
- Interbank markets:
  - Duffy, Karadimitropoulou, Parravano (2019) implemented Allen and Gale (2000) model of network of banks.
  - Choi, Gallo, Wallace (2017) implemented Acemoglu et al. (2015) model of network of banks.
  - Davis, Korenok, Lightle (2019) implemented Allen and Gale (2004) model of interbank market.

Experimental Design

- **3 or 4 stage game:** Elements of Allen, Carletti, and Gale (2009), Gale and Yorulmazer (2013)

- **Stage 0**
  - 8 banks, each endowed with $12 in deposits
  - Portfolio decision
    - **Assets** – cost $1, yield $2 in final period
    - **Cash** – return of 0, but can be used to meet withdrawals and to purchase assets

Experimental Design

- **Stage 1 (and 2)**
  - Liquidity shocks occur (withdrawals from banks)
  - Banks that need cash may sell assets to banks with excess cash (interbank market)
  - If can’t meet cash withdrawal, bank fails, bankruptcy cost is $4.00

- **Final stage**
  - Assets mature, deposits repaid, earnings determined

Two Environments: Simple/Compound Shock

- **Simple Shock** (3 stage game)
  - Stage 1
    - 4 randomly selected banks receive a withdrawal request of $8
- **Compound Shock** (4 stage game)
  - Stage 1: Same as in Simple Shock game
  - Stage 2
    - With probability 0.5, 2 of the 4 banks that did ***not*** receive a stage 1 shock, now receive an $8 shock.

Two Liquidity Regimes

- **Unregulated:** Banks choose how much cash to hold

- **Liquidity requirements**
  - Banks must hold $4 in cash
    - when making investment decision
    - If not hit by a shock (can sell only cash above $4)

Four Treatments

- Baseline, Simple shock (BS)
- Liquidity requirement, Simple shock (LS)
- Baseline, Composite shock (BC)
- Liquidity requirement, Composite shock (LC)

Interbank Trading

- Double auction (Davis, Korenok, Lightle 2019)
  - Supply has negative slope, lots of possible prices, hard to make predictions
- Our choice:
  - Aggregate cash needs displayed to everyone
  - Banks with excess cash decide how much to supply
  - Price:
    - Supply < Demand => all cash supplied is sold=> price is $1 per 1 asset
    - Supply > Demand => extra cash on the market => price is $2 per 1 asset

Allocation of Cash in case of Shortage

- Example, Bank A needs $2, Bank B needs $3, Bank C needs $4. Other banks only supply $7.
  - P = $1 because supply ($7) < demand ($9).
  - Allocate $2 to Bank A, $2 to Bank B, and $2 to Bank C. The 7^{th} dollar is allocated randomly to B or C.

Payoffs

- Payoffs
  - Failure/Bankruptcy (can’t meet withdrawals in either period)
    - Period earnings = -$4.00
  - If don’t fail
    - Period earnings = $2*final assets + final cash – final deposits
  - If just held cash for the entire game get $0.00.
  - If only hold assets and get no liquidity shocks, get $12.00.

Autarkic prediction for all treatments

- No trade
  - t = 0: 64 cash, 32 investment
- Way to implement
  - t = 0: each bank holds 8 cash and invests 4
  - t = 1: 4 banks get withdrawal shock of 8 each, they have enough cash on hands
  - t = 2: 4 banks have 4 assets, 8 cash, 12 deposits; 4 banks have 4 assets, 0 cash, 4 deposits
  - Expected earnings = 0.5(4) + 0.5(4) = 4

Baseline, Simple Shock (BS)

- Best that can be done
  - t = 0: 32 cash, 64 investment
- Unique symmetric subgame perfect Nash equilibrium (SPNE)
  - t = 0: each bank holds 4 cash and invests 8
  - t = 1: 4 banks get withdrawal shock of 8 each
    - Need 16 more cash
    - 4 banks without shocks have 16 in excess cash, which they supply
    - P = 1
  - t = 2: 4 banks have 12 assets, 0 cash, 12 deposits; 4 banks have 4 assets, 0 cash, 4 deposits
  - Expected earnings = 0.5(12) + 0.5(4) = 8

Liquidity Requirement, Simple Shock (LS)

- Liquidity requirement is 4
- Unique Symmetric SPNE
  - t = 0: each bank holds 6 cash and invests 6
  - t = 1: 4 banks get withdrawal shock of 8 each
    - Need 8 more cash
    - 4 banks without shocks have 8 (2 each) in excess cash, which they supply
      - Liquidity requirement makes them hold onto 4 each
    - P = 1
  - t = 2: 4 banks have 10 assets, 4 cash, 12 deposits; 4 banks have 2 assets, 0 cash, 4 deposits
  - Expected earnings = 0.5(12) +0.5(0) = 6

Baseline, Composite Shock (BC)

- No exposure symmetric SPNE
  - t = 0: each bank holds 6 cash and invests 6
  - t = 1: 4 banks get withdrawal shock of 8 each
    - Need 8 more cash, other 4 banks supply 8 cash, P = 1
  - t = 2: no shock, game ends
  - t=2: shock, 2 banks hit with shock have 4 cash, so need 4 more
    - 2 banks without shock, each supply 4, P = 1
  - No failures
  - Expected payoff = $6

Baseline, Composite Shock (BC)

- Exposure symmetric SPNE
  - t = 0: each bank holds 4 cash and invests 8
  - t = 1: 4 banks get withdrawal shock of 8 each
    - Need 16 more cash, other 4 banks supply 16 cash, P = 1
  - t = 2: no shock, game ends
  - t=2: shock, 2 banks hit with shock have 0 cash and fail
  - Two failures
  - Expected payoff = $6
- More investment than no-exposure equilibrium, but offset by the two failures

Liquidity Requirement, Composite Shock (LC)

- No exposure symmetric SPNE
  - t = 0: each bank holds 7 cash and invests 5
  - No failures in t=1 or t = 2

- Exposure symmetric SPNE
  - t = 0: each bank holds 6 cash and invests 6
  - No failures in t=1, but 2 failures at t = 2 if shock

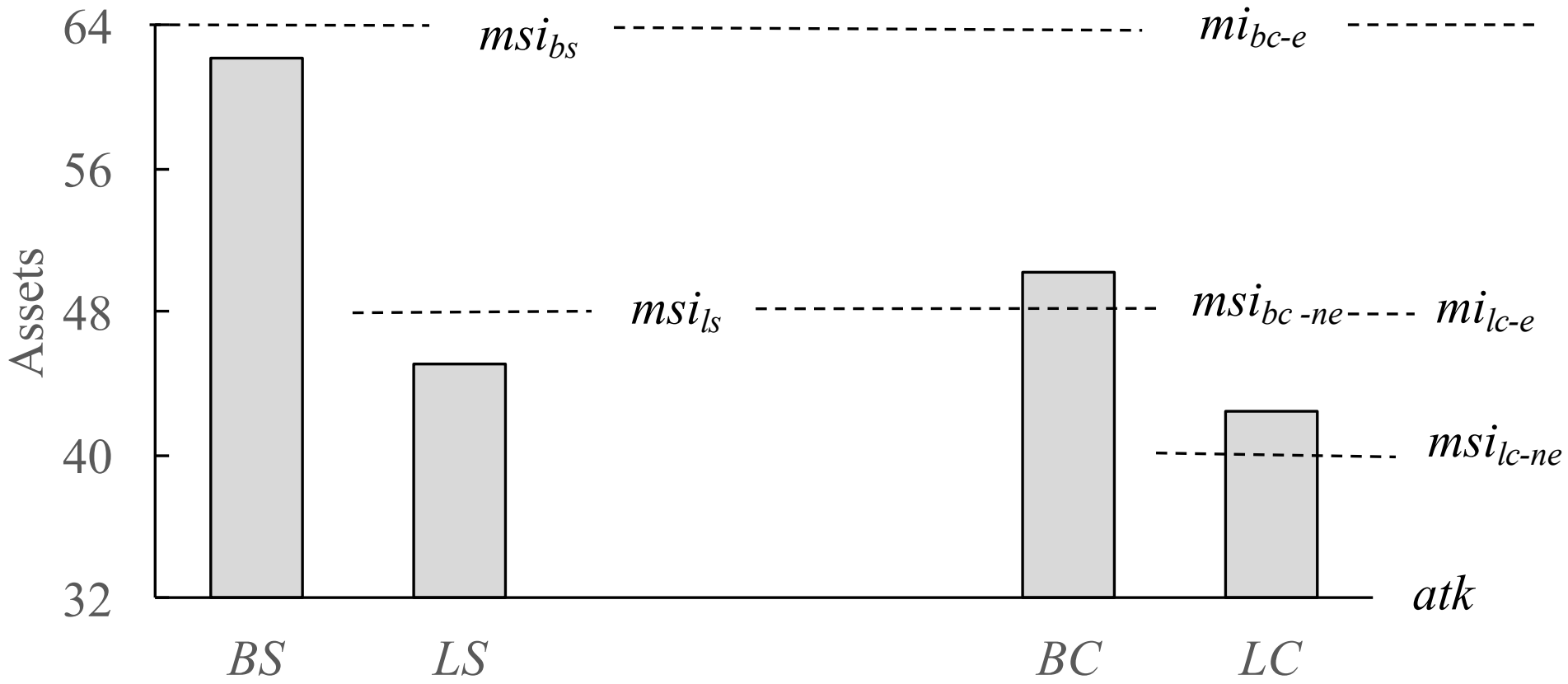
Equilibrium Predictions

Table 1. Equilibrium Predictions			
Treatment	Period 0 cash	Expected Payoff	Investment
BS	$4	$8.00	64
BC – *ne*	$6	$6.00	48
BC – *exposure*	$4	$6.00	64
LS	$6	$6.00	48
LC – *ne*	$7	$5.00	40
LC– *exposure*	$6	$4.50	48
Autarkic	$8	$4.00	32

Experiment Procedures

- 12 sessions. Each session consisted of two 8-bank markets.
- In total 24 independent markets, 6 in each treatment.
- Results based on 18 periods in each market.
- 196 undergrads at VCU.
- Earnings ranged from $15.60 to $45.00 and averaged $29.20 for 90 minutes sessions.

Investment Results



Investment Results

- Investment exceeds autarkic levels ($32)
  - Players relying on interbank market to meet withdrawals
- Quite close to SPNE-no exposure equilibria
  - Simple shock – less investment
  - Compound shock – modestly higher investment
- Liquidity requirements
  - Reduces investment (as predicted with no exposure equilibria)

Investment Results

Table 2 Initial Investments

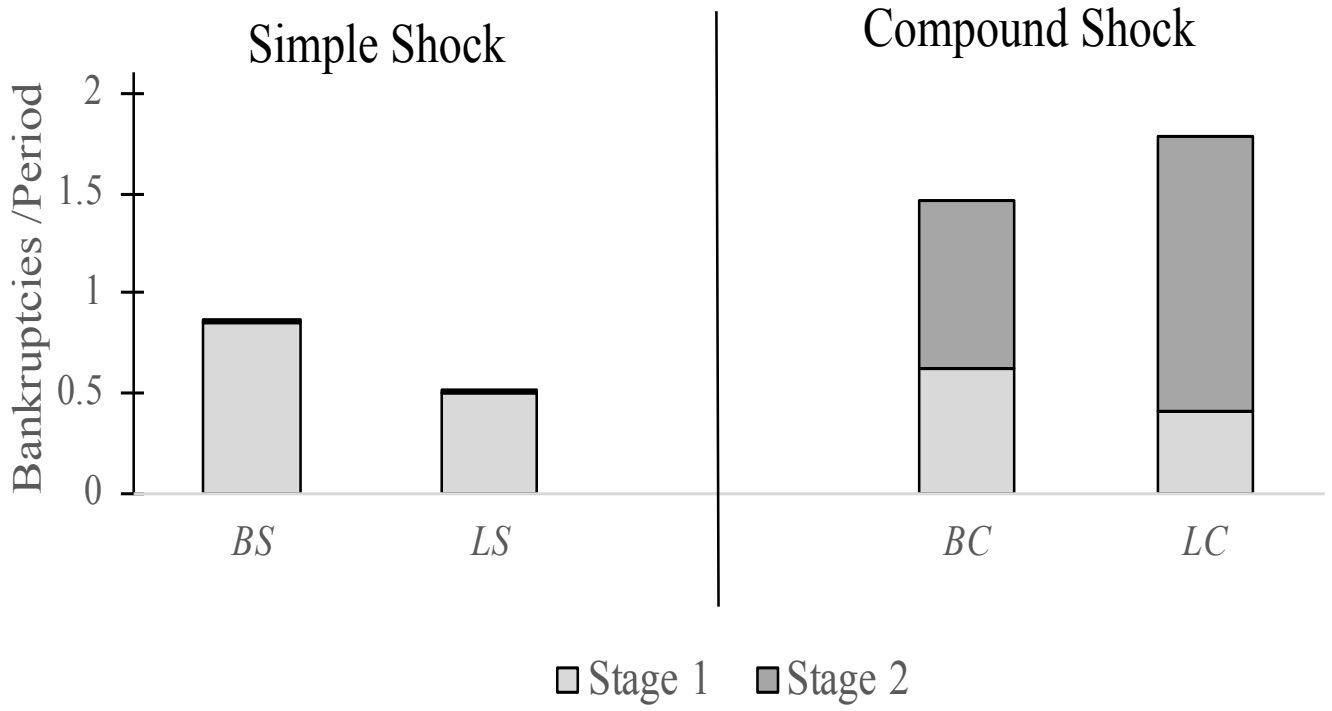
(1) Treatment	(2) $\overline{inv_i}$	(3a) *msi*	(3b) $\overline{inv_i}$-*msi*	(4a) *ei-e*	(4b) $\overline{inv_i}$- *ei-e*	(5) *BS-LS*	(6) *BC-LC*
BS	62.08	64	-1.92*				
LS	45.06	48	-2.94***			17.02***	
BC	50.15	48	2.15	64	-13.85***		
LC	42.34	40	2.34***	48	-5.66***		7.81***

Key: $\overline{inv_i}$ denotes mean initial investment, *msi* denotes maximum sustainable investment, and *ei-e* denotes equilibrium investment in the exposure equilibrium (for the *BC* and *LC* treatments only). *, ** and *** denote rejections of the null that the listed difference equals zero, $p<0.10$, 0.05 and 0.01, respectively. In all treatments $\overline{inv_i}$ exceeds the autarkic level of 32 units at $p<0.01$.

Calculated from regression: $y_{it} = \beta_0 + \beta_L D_L + \beta_C D_C + \beta_{CL} D_C D_L + \varepsilon_i + u_{it}$

Failure Results

- Overall: Bankruptcies occur
- Simple Shock: Bankruptcies less frequent with liquidity regulations.
- Compound Shock: Liquidity requirements reduce first-stage bankruptcies, but increase second-stage bankruptcies.



Failure Rates

Table 3 Bankruptcies (Average per Period)

(1) Treatment-Period	(2) 1st Stage Rate	B - L	(3) 2nd Stage Rate	B - L	(4) Total Rate	B - L
All Periods						
Simple Shock Environment						
BS	0.85		---		0.85	
LS	0.51	0.34***	---	---	0.51	0.34***
Compound Shock Environment, Second Stage Shock						
BC	0.62		0.86		1.47	
LC	0.41	0.21	1.38	-0.52**	1.77	-0.30

Bankruptcies in Simple Shock Environment

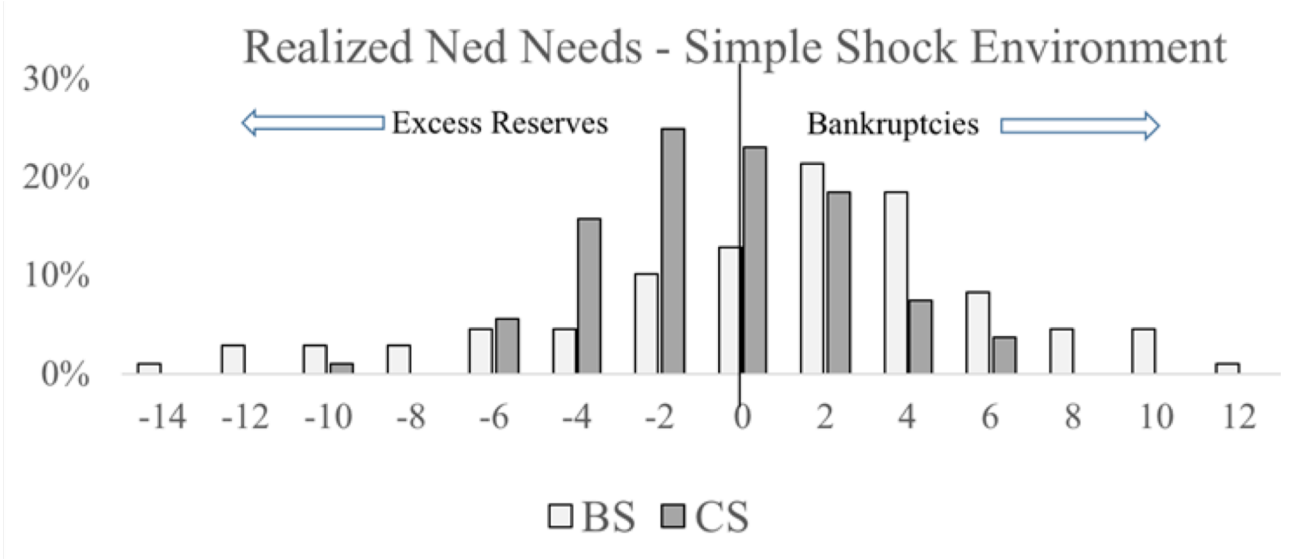
- SPNEs predicts no bankruptcies.
  - Reason: average investment levels hide high variation in individual decisions
  - Players even change strategies over time
  - Only need one more unit of investment greater than the maximum sustainable level to get a bankruptcy.

Variation in Individual Strategies

Table 4. Homogeneity and Stability of Individual Investment Decisions

Treatment	*BS*	*LS*	*BC*	*LC*
Symmetric SPNE Investment ('SNE')				
	8	6	6	5
Homogeneity of Individual Investment Decisions				
<SNE-3	11%	0%	0%	0%
<SNE-1	32%	33%	35%	0%
SNE	28%	29%	18%	20%
>SNE+1	20%	18%	25%	18%
>SNE+3	13%	0%	13%	0%
Change in Investment Decisions Across Periods				
No change	50%	57%	54%	54%
+2 or more	29%	25%	27%	26%
+4 or more	12%	6%	12%	5%
+6 or more	5%	0%	7%	0%

Variation in Net Needs for Liquidity



With excess reserves P=2, otherwise P = 1. At least one bank will be bankrupt if net needs is positive.
No bankruptcy with excess reserves.
Some banks with cash would hold not release it in order to try and get P=1. Strategic motivation to hoard liquidity.

Summary

- Looking at how liquidity regulation affect the interbank market

- Our results suggests high costs to these regulations
  - Significant cost in foregone investment
  - Pulls liquidity out that could help in the interbank market

- Empirical question: Does interbank market plays an important role during panic or it freezes?
  - If interbank freezes => liquidity regulations help
  - If interbank still works => regulations hurt the market

Summary/Caveats

- Paper is exploratory
  - Very sparse environment
  - Lot of departures from observed institutions
    - Cash leaves system – like a currency withdrawal, not a transfer of reserve on a central bank balance sheet
    - No central bank
    - Trade is stylized
  - Very large liquidity shocks
- We view as a first step towards finding a useful experimental design for interbank market questions