Banks, Liquidity Management and Monetary Policy

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Central Banks have been facing unprecedented conditions in financial markets

- Deterioration of banks’ balance sheet, collapse in bank lending, weak demand for credit, drop in money multiplier, liquidity trap
Introduction

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  - Deterioration of banks’ balance sheet, collapse in bank lending, weak demand for credit, drop in money multiplier, liquidity trap

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- **Want**: model of banks’ liquidity management to understand transmission of monetary policy
Model Overview

1. Liquidity Management Tradeoff
   - (+) Profit on Loans
     - Spread between **illiquid loans** and liquid liabilities (deposits, credit lines)
   - (-) Illiquidity Risk
     - Liabilities may be transferred, may be forced to borrow

2. Monetary Policy
   - Liquidity channel: MP affects banks' tradeoff between extending loans and holding liquid assets

3. Tractability
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Quantitative Application

Why are banks stockpiling cash rather than lending?
Quantitative Application

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Four Hypothesis

1. Equity Losses
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2. Capital Requirements
Quantitative Application

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3. Uncertainty in Interbank markets
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1. Equity Losses
2. Capital Requirements
3. Uncertainty in Interbank markets
4. Weak Loan Demand
1. Banks’ Liquidity Management
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2. Equilibrium Stochastic Steady State
   ○ Static Demand for Loans
1. Banks’ Liquidity Management

2. Equilibrium Stochastic Steady State
   - Static Demand for Loans

3. Transitional Dynamics Experiments
1. Banks’ Liquidity Management

2. Equilibrium Stochastic Steady State
   ◦ Static Demand for Loans

3. Transitional Dynamics Experiments

4. Estimation of the model to evaluate four hypothesis (in progress)
Model
Model - Environment

- **Time:** \( t=1,2,3,\ldots \)
Model - Environment

- **Time:** $t=1,2,3,\ldots$
  
  - **Two stages:** $s=l,b$
    
    - Lending stage (l) and balancing stage (b)
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- Continuum of Heterogeneous Banks $z \in [0,1]$
Model - Environment

- **Time:** $t=1,2,3,...$
  - Two stages: $s=l,b$
    - Lending stage ($l$) and balancing stage ($b$)

- Continuum of Heterogeneous Banks $z \in [0,1]$

- **Utility function:** Concave utility $U$ over dividends $div_t$
Liabilities:

- $D_t$ demand deposits \((\textit{numeraire})\)
Bank’s State Variable - Bank Balance Sheet

- **Liabilities:**
  - $D_t$ demand deposits (*numeraire*)

- **Assets:**
  - $C_t$ reserves (only traded among banks or with central bank)
  - $B_t$ loans
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- **Equity**
  - $N_t = q_t B_t + C_t (1 + r) - D_t$
Liquidity Management

Bank Balance Sheet
Liquidity Management

Bank Balance Sheet
Loans $B_t$

- Loans: perpetual securities (long maturity)
  - Decaying-coupon Consol
Loans $B_t$

- Loan contract specifies:
  1. price $q_t$
  2. Face value $I_t$
  3. $q_t^l I_t$ checks given to firms or households
Loans $B_t$

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- Repayment:
  - $I_t \left((1 - \delta), (1 - \delta)\delta^2, \ldots (1 - \delta)\delta^n\right)$ in period 1, 2, ..., $n$
Recursively, the bank loans can at date $t+1$ equal:

$$B_{t+1} = \delta B_t + I_t$$
Loans $B_t$

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Loans $B_t$

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- Loan is illiquid:
  - Lending stage: Loans **can** be sold
  - Balancing stage: Loans **cannot** be sold
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- Loan is illiquid:
  - Lending stage: Loans can be sold
  - Balancing stage: Loans cannot be sold

- Downward sloping demand for loans
  - $I_t^d = \Theta_t (1 + r_t^L)^\varepsilon$
Deposits $D_t$

- **Lending Stage**: Choice of deposits subject to Leverage Constraint
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  - $D_t \leq \kappa N_t$
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- **Balancing Stage:**
  - $\omega \in (-\infty, 1]$ random fraction of $D_t$ may leave
    - Randomness in payments system and deposit holdings
  - Withdrawal, pay other bank with reserves
    - $\omega \sim F_t(\omega)$
    - $\mathbb{E}(\omega) = 0$ - deposits don’t leave the bank system
Deposits $D_t$

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- Penalty for insufficient reserves: $\chi(C, D)$.
- In particular, $\chi(\rho D_t - C_t)$

\[
\chi_t(x) = \begin{cases} 
\chi x & \text{if } x \leq 0 \\
\overline{\chi} x & \text{if } x > 0 
\end{cases}
\]

where $\rho_t \in [0, 1]$ represent a reserve requirement
Reserves $C_t$

- Fixed Aggregate Supply determined by central bank: $M0_t$

- Transferred across banks
  - Loan withdrawal
  - Interbank purchases $\varphi_t$

- Precautionary motive
  - Avoid penalty $\chi$
Liquidity Management

Bank Balance Sheet - Liquid Assets
Central Bank Tools

- Interest rate and Reserve Requirements:
- OMO: purchase of Loans or Deposits for Reserves
- $\kappa$ capital requirements
Aggregate States

- Governments Policy Path \( \{ \rho_t, M0_t, D_t^G, B_t^G, \kappa_t, \chi_t, \bar{\chi}_t \}_{t \geq 0} \)

- \( \Theta_t \) is the slope of demand curve.

- \( F_t \) process for withdrawal risk

- Potentially: Distribution of Bank state variables
  - Only one endogenous state variable \( E_t \)

- Aggregate State Summarized: \( X_t \)
  - Model recursive in \( X_t \)
Value Function - Lending Stage

\[ V^l(C, B, D; X) = \max_{I, \varphi, DIV} u(DIV) + \beta E_{\omega'}[V^b(\tilde{C}, \tilde{B}, \tilde{D}, \omega'; X)] \]

\[ \tilde{D} = D + qI + DIV + \varphi(1 + r) - B(1 - \delta) \]

\[ \tilde{C} = C + \varphi \]

\[ \tilde{B} = \delta B + I \]

\[ \tilde{D} \leq \kappa(\tilde{B}q + \tilde{C}(1 + r) - \tilde{D}), \tilde{D} \geq 0. \]
Value Function - Lending Stage

\[ V^l(C, B, D; X) = \max_{I, \phi, \text{DIV}} u(\text{DIV}) + \beta E_{\omega'}[V^b(\tilde{C}, \tilde{B}, \tilde{D}, \omega'; X)] \]

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Value Function - Balancing Stage

\[ V^b (C, D, B, \omega; X) = \beta \mathbb{E}[V^l (C', B', D'; X')] \]

subject to

\[ C' = C - \omega D \]
\[ D' = D - \omega D + \chi (\rho D (1 - \omega) - C') \]
\[ B' = B \]
One Value Function

\[ V^l(C, B, D; X) = \max_{\{I, DIV, \tilde{C}, \tilde{D}\} \in \mathbb{R}^4} U(DIV) \cdots \]

\[ + \beta \mathbb{E} \left[ V^l(\tilde{C} - \omega' \tilde{D}, \tilde{B}, \tilde{D}(1 - \omega') + \chi(\rho \tilde{D} - (\tilde{C} - \omega' \tilde{D})); X')|X \right] \]

\[ \tilde{D} = D + qI + DIV + \varphi(1 + r) - B(1 - \delta) \]

\[ \tilde{B} = \delta B + I \]

\[ \tilde{C} = \varphi + C \]

\[ \tilde{D} \leq \kappa(\tilde{B}q + \tilde{C}(1 + r) - \tilde{D}), \tilde{D} \geq 0. \]
Equilibrium

- Initial conditions
- Government sequence $\left\{ \rho_t, M_0, D_t^G, B_t^G, \kappa_t, \chi_t, \overline{\chi}_t \right\}_{t \geq 0}$
- Bank choices $\{C_t, B_t, D_t, DIV_t\}_{t \geq 0}$
- And prices $\{q_t, r_t\}_{t \geq 0}$
- Optimality of choices given prices
- Money Market Clears:
  \[ \int_{0}^{\infty} C_t(z) \, dz = M_0, \forall t \]
- Loan Market Clears
  \[ I_t^S = \int_{0}^{\infty} \Delta B_{t+1}(z) \, dz + \int_{0}^{\infty} \Delta B_{t+1}^G(z) \, dz, \]
  and
  \[ I_t^D = \Theta_t^{-1} \left( q_t \right)^{\frac{1}{\epsilon}} = I_t^S. \]
Theory Characterization
Characterization

1. Single endogenous state
Characterization

1. Single endogenous state

2. Portfolio Separation Theorem
   - Dividend-Savings independent of Portfolio Weights
Liquidity Premium

- Banks require a higher return on loans relative to cash:

\[ R^B - R^C = E_\omega' \chi' + \frac{Cov(m_{t+1}, \chi')}{E_\omega'm_{t+1}} \]

- \( m_{t+1} \) is the SDF

- Monetary policy can affect lending by altering the liquidity premium
## Calibration

### Parameter Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital requirement</td>
<td>$\kappa = 17$</td>
<td>6% Tier-2 Capital</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta = 0.99$</td>
<td>Return on Equity=8%</td>
</tr>
<tr>
<td>Risk aversion</td>
<td>$\gamma = 1$</td>
<td>Benchmark</td>
</tr>
<tr>
<td>Loan Maturity</td>
<td>$\delta = 0.5$</td>
<td>Residual duration + buy-backs</td>
</tr>
<tr>
<td>Interest rate (annualized)</td>
<td>$r = 4%$</td>
<td>LIBOR</td>
</tr>
<tr>
<td>Liquidity Requirement</td>
<td>$\rho = 0.10$</td>
<td>Res. Req.</td>
</tr>
<tr>
<td>Loan Demand Elasticity</td>
<td>$\epsilon = 8.0$</td>
<td>-</td>
</tr>
<tr>
<td>Penalty</td>
<td>$\chi^L = 0.0%$</td>
<td>FedRate</td>
</tr>
<tr>
<td>Penalty</td>
<td>$\chi^H = 3.2%$</td>
<td>Liquidity Ratio</td>
</tr>
<tr>
<td>Withdrawal-shock volatility $F_t$</td>
<td></td>
<td>Non-Param Data</td>
</tr>
</tbody>
</table>
Cross-Sectional Distribution of Deviation from Cross-Sectional Average Growth Rates
Why are banks stockpiling cash rather than lending?
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Four Hypothesis

1. Equity Losses
2. Capital Requirements
3. Uncertainty in Interbank markets
4. Weak Loan Demand
Estimation Strategy: Four shocks

- We calibrate:
  - Equity losses resulting from subprime (4 % of equity)
  - Raise in capital requirements according to Basel III (2.5 % of extra capital)
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  1. the initial shock,
  2. persistence,
  3. time of the shock
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- These parameters are set to minimize distance between model transition in first 7 years and the sequence of reserves, dividend rates and lending observed in the data
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- Evaluate the magnitude of the shocks and the relative importance of each shock
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Preview of Results

- Equity Losses and Capital Requirements: similar effects
  - Contraction in lending volumes
  - Drop in cash holdings
  - Drop in dividend rates
  - Rise in spreads

- Withdrawal risk and demand shocks
  - Both generate increase in cash holdings
  - But they differ in prediction for spreads and dividend rates
    - Withdrawal risk predicts fall in dividends and increase in spreads
    - Demand shocks predict increase in dividends and decrease in spreads

- Preliminary results provide prominent role to withdrawal risk and demand shocks

- We infer that economy was first hit by withdrawal risk and then by fall in demand due to evolution of dividends
Workings of the Model

- Deterministic Transitional Dynamics
Workings of the Model

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- Steady-state:
Workings of the Model

- Deterministic Transitional Dynamics

- Steady-state:
  - Fix $\{\rho_t, M0_t, \kappa_t, \underline{\chi}_t, \overline{\chi}_t\}_{t \geq 0}$
  - Find $(q,r)$ such that equity doesn’t grow
  - Solve for $E$: financial sector size
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- Transitional Dynamics: one shock at a time
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  - Solve for \( E \): financial sector size

- Transitional Dynamics: one shock at a time
  - Find \( (q_t, r_t) \), consistent with equity growth and convergence
Equity Loss - $E_0$ by 4 percent
Permanent Rise in Capital Requirements - (AR-1 process, extra 2.5 % capital)
Perman. Rise in Cap. Requirements

![Graphs showing the relationship between equity, total lending, return on loans, and total cash.](image)
Permanent Rise in Cap. Requirements

---

**Lending Rate (b)**

**Reserve Rate (c)**

**Dividend Rate (div)**

**Portfolio Value (\( \Omega \))**

**Bank Value**

**Liquidity Risk**
Shock to probability of bank-run (AR-1 process, initial increase is 10 percent)
Bank-run Risk

Equity

Total Lending

Return on Loans

Total Cash

39
Bank-run Risk

- Lending Rate (b)
- Reserve Rate (c)
- Dividend Rate (div)
- Portfolio Value ($\Omega$)
- Bank Value
- Liquidity Risk
Loan Demand Shock - $\downarrow \Theta_t$ (AR (1) process, 20 percent initial decrease)
Demand Shock

Equity

Return on Loans

Total Lending

Total Cash
Demand Shock

- Lending Rate (b)
- Reserve Rate (c)
- Dividend Rate (div)
- Portfolio Value (\(\Omega\))
- Bank Value
- Liquidity Risk
Transitory Reduction in $\chi$ (20% initial reduction, AR-1 process)
Transitory Reduction in $\chi$

**Equity**

- $\chi$ decreases initially, then stabilizes around 0.

**Total Lending**

- $\chi$ decreases significantly initially, then stabilizes.

**Return on Loans**

- $\chi$ increases rapidly to a peak, then stabilizes around 0.

**Total Cash**

- $\chi$ decreases rapidly to a peak, then stabilizes around 0.
Transitory Reduction in $\chi$
Transitory Reduction in $r$ (50 % initial reduction, AR-1 process)
Transitory Reduction in $r$

![Graphs of Equity, Total Lending, Return on Loans, Total Cash](image)

**Equity**
- The graph shows a slight decrease in equity over time, with a peak around 50 and a slight decline thereafter.

**Total Lending**
- The graph indicates a sharp increase in total lending, reaching a peak around 50 and then stabilizing.

**Return on Loans**
- The graph displays a sharp decline in return on loans, starting from a high value and decreasing rapidly to a low.

**Total Cash**
- The graph shows a dramatic decrease in total cash, starting from a high value and dropping sharply to a low.
Transitory Reduction in $r$

<table>
<thead>
<tr>
<th>Lending Rate (b)</th>
<th>Reserve Rate (c)</th>
<th>Dividend Rate (div)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.02</td>
</tr>
<tr>
<td>50</td>
<td>2.3</td>
<td>0.02</td>
</tr>
<tr>
<td>100</td>
<td>15.4</td>
<td>0.02</td>
</tr>
</tbody>
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<table>
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<tr>
<th>Portfolio Value ($\Omega$)</th>
<th>Bank Value</th>
<th>Liquidity Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0002</td>
<td>1.5</td>
</tr>
<tr>
<td>50</td>
<td>1.0002</td>
<td>1.6</td>
</tr>
<tr>
<td>100</td>
<td>1.0002</td>
<td>1.7</td>
</tr>
</tbody>
</table>
Conclusions

- We developed a model of banks’ liquidity management
- Monetary policy has real effects via a liquidity channel
- Quantitative analysis suggests that demand shocks and uncertainty about the risk of bank-runs played a prominent role in the US financial crises