Liquidity Management and Monetary Policy

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Introduction

• During last five years monetary policy has changed
Introduction

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• Facts:
  1. Interbank market disruption
  2. Zero lower bound
  3. Unconventional open market operations
  4. Excess reserves holdings
  5. Lending not resumed
  6. Money multiplier at floor
Introduction - Fed Funds

Figure: Fed Funds Rate 2002-2012

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Liquidity and Money
Introduction - Fed Funds Off Target

Figure: Fed Funds Rate 2008-2010

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Liquidity and Money
Figure: Fed Balance Sheet 2002-2012

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Liquidity and Money
Introduction - Open Market Operations

Figure: Fed Balance Sheet 2002-2012

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Liquidity and Money
Introduction - OMO + Lending

Figure: Fed Balance Sheet 2002-2012

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Liquidity and Money
Introduction - OMO + Lending

Figure: Fed Balance Sheet 2002-2012

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Introduction - OMO + Lending

Figure: Fed Balance Sheet 2002-2012

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Figure: Fed Balance Sheet 2002-2012
Introduction - OMO + Lending + Facilities + Real

Figure: Fed Balance Sheet 2002-2012

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Introduction - Required Reserves

Figure: Reserves at Commercial Banks

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Liquidity and Money
Introduction - Required vs. Excess Reserves

Figure: Reserves at Commercial Banks
Introduction - Unresumed lending

Figure: Lending of Commercial Banks

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Introduction - Deleveraging

Figure: Total Liabilities of Commercial Banks

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Liquidity and Money
Introduction

Figure: Total Liabilities of Commercial Banks
Summary

- Facts cast doubts about effectiveness
  - Ability to stimulate the economy
  - Lead to inflation?
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  ○ Ability to stimulate the economy
  ○ Lead to inflation?

• View
  ○ Financial sector at epicenter of crisis
  ○ Monetary policy operates through the banking system
  ○ Task: understand transmission of MP through banks
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  - Ability to stimulate the economy
  - Lead to inflation?

- View
  - Financial sector at epicenter of crisis
  - Monetary policy operates through the banking system
  - Task: understand transmission of MP through banks

- Model: realistic description of bank problems
Problems Banks Face

1. Liquidity management problem
   ○ Trade-off profit on loans against losses due to illiquidity
Problems Banks Face

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   - Trade-off profit on loans against losses due to illiquidity

2. Risk-management
   - Leverage increases profits, exposes to excessive risk
   - Interest rate risk, credit risk
Problems Banks Face

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   ◦ Trade-off profit on loans against losses due to illiquidity

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   ◦ Interest rate risk, credit risk
Questions

- How does a monetary stimulus depend on leverage and liquidity ratios?
  - Particular emphasis on stress times
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• How does a monetary stimulus depend on bank regulation?
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- How does a monetary stimulus depend on leverage and liquidity ratios?
  - Particular emphasis on stress times

- How does a monetary stimulus depend on loan maturity and floating rates?

- How does a monetary stimulus depend on bank regulation?

- Ability to neutralize a monetary stimulus?
Literature Review

1. Call for modeling banks in transmission:
   ○ Woodford (2010, JEP), Mishkin (2012), Boldrin (2012), Sims, Lucas

2. Related Paper
Literature Review

1. Call for modeling banks in transmission:
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2. Related Paper

3. Implementation models and Unconventional Policy
   ○ Lagos-Afonso (2012), Stein(2012)
   ○ Gertler-Kiyotaki (2011,2012), Gertler-Karadi (2010),
     Curdia-Woodford (2012)

4. Empirical Work
   ○ Krishnamurthy-Vissing-Jorgenson (JPE 2012,2012b),
     Nakamura-Steinsson (2012)

5. Classic Work
   ○ Frost (JPE,1971), Freeman(AER,1985), Sargent-Wallace Irrelevance

6. Liquidity Management
   ○ Saunders-Millon-Cornett (2011), Brunnermeier-Pedersen
     (2009,RFS)
Agenda

1. Description of Liquidity Management Problem
Agenda

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2. Dynamic Programming Problem
   - Description of Bank Policy Functions
Agenda

1. Description of Liquidity Management Problem

2. Dynamic Programming Problem
   ○ Description of Bank Policy Functions

3. Policy Exercises
Liquidity Management
Textbook Explanation
Liquidity Management.

Figure: Bank Balance Sheet
Liquidity Management.

**Figure:** Bank Balance Sheet - Liquid Assets
Liquidity Management.

Figure: Bank Balance Sheet - Asset Expansion
Liquidity Management.

**Figure:** Bank Balance Sheet - Money Creation
Liquidity Management.

Figure: Bank Balance Sheet - Asset Expansion
Liquidity Management.

**Figure:** Random Withdrawal
Liquidity Management.

**Figure:** Withdrawal in Excess of Reserves
Liquidity Management.

Figure: Required Borrowing
Liquidity Management.

Figure: Required Borrowing
Liquidity Management.

**Figure:** Required Borrowing
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Figure: Required Borrowing
Liquidity Management.

Figure: Required Borrowing
Figure: Required Borrowing - Equity Losses
Liquidity Management.

Figure: Required Borrowing - Equity Losses

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Economic Forces behind Liquidity Management

- Loans granted by issuing deposits
Economic Forces behind Liquidity Management

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- Loans are profitable but induce liquidity risk
  - Value of currency to deposits shrinks
Economic Forces behind Liquidity Management

- Loans granted by issuing deposits
- Loans are profitable but induce liquidity risk
  - Value of currency to deposits shrinks
- Trade offs determine lending & borrowing rates and credit
Liquidity Management and Monetary Policy

- Monetary Policy Instruments
  - Open-market operations
  - Discount window
  - Reserve requirements
Liquidity Management and Monetary Policy

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- Change trade-offs between in Liquidity Management Problem
Liquidity Management and Monetary Policy

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  - Open-market operations
  - Discount window
  - Reserve requirements

- Change trade-offs between in Liquidity Management Problem

- Inflation and output via bank decisions
  - Interest Rates
  - Volume of Credit
Liquidity Management - OMO

Figure: Bank Balance Sheet
Figure: Bank Balance Sheet
Liquidity Management - OMO

After withdrawal shock

WITH OMO

WITHOUT OMO

Figure: Bank Balance Sheet
Liquidity Management and Monetary Policy

- **FED - OMO**
  - Should reduce liquidity risk
  - Ex-ante liquidity shock, expand loans

- In crisis, this transmission channel was broken...
Without loans expanding...
- M1,M0 up
- Multiplier down.
- Excess Reserves up
- Fed Balance sheet expanding

Figure: Bank Balance Sheet
Liquidity Management and Monetary Policy

- FED - OMO, discount window rate (FedFunds)...
  - Should expand loans
  - Channel is broken...

- Friedman’s recipe...

- What’s going on?
Liquidity Management
Dynamic Model
Model Features

- Rational and heterogeneous commercial banks
Model Features

- Rational and heterogeneous commercial banks
- Trade-off between profiting from loans and exposing to withdrawal risk
Model Features

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- Trade-off between profiting from loans and exposing to withdrawal risk
- Partial Equilibrium
Model Features

• Rational and heterogeneous commercial banks

• Trade-off between profiting from loans and exposing to withdrawal risk

• Partial Equilibrium

• Benchmark to Study Monetary Policy
Observables

- Individual States:
  - Leverage Ratio
  - Liquidity Ratio
Observables

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  - Leverage Ratio
  - Liquidity Ratio

- Given cross-section distribution of ratios
  - Aggregate lending
  - Interbank borrowing
  - Dividends
Outcomes

• Endogenous monetary creation
  ○ Endogenous money multiplier
Outcomes

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  ○ Endogenous money multiplier

• In general equilibrium...
Outcomes

- Endogenous monetary creation
  - Endogenous money multiplier

- In general equilibrium...

- Endogenous lending and borrowing rates
Outcomes

- Endogenous monetary creation
  - Endogenous money multiplier

- In general equilibrium...

- Endogenous lending and borrowing rates

- Endogenous pass-through from policy rates to lending rates
  - Liquidity effect
Model - Environment

● Partial Equilibrium
Model - Environment

- Partial Equilibrium

- Time: $t=1,2,3,\ldots$
Model - Environment

- Partial Equilibrium

- Time: $t=1,2,3,\ldots$

  - Two stages: $s=l,b$.
  - Lending stage (l) and cash-management stage (b).
Model - Environment

- Partial Equilibrium

- Time: $t=1,2,3,...$
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- Continuum of Heterogeneous Banks
Model - Environment

- Partial Equilibrium

- Time: $t=1,2,3,\ldots$
  - Two stages: $s=l,b$.
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- Continuum of Heterogeneous Banks

- Utility function: Concave utility $U$ over dividends $d_t$.
Model - Technology

- Loans Demand
  - Loans (credit) facilitates transactions
  - Repayment promise not enough
Model - Technology

- **Loans Demand**
  - Loans (credit) facilitates transactions
  - Repayment promise not enough

- *Evil is the root of all money*
  - Only banks can enforce credit
  - Bank becomes liable to borrower’s default (KM, 2002)
Bank’s State Variable - Bank Balance Sheet

- Liabilities:
  - \( D_t \) demand deposits.
Bank’s State Variable - Bank Balance Sheet

• Liabilities:
  ○ $D_t$ demand deposits.

• Assets:
  ○ $C_t$ reserves
  ○ $B_t$ loans
Model - Loans

- Loans: perpetual securities owed by firms
  - Truthful repayment commitment to
- Loan contract specifies price $q_t^l$ and face value $I_t$
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- Loan contract specifies price $q^l_t$ and face value $I_t$
- Repayment $I_t (1 - \delta) \delta^n$ in period $t + n$ for all $n \geq 0$
  - Deterministic geometrically decaying:

  $(1 - \delta)$
Model - Loans

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    (1 - \delta), (1 - \delta) \delta, (1 - \delta) \delta^2,
    \]
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  - Deterministic geometrically decaying:

  $$(1 - \delta), (1 - \delta) \delta, (1 - \delta) \delta^2, (1 - \delta) \delta^3...$$
Model - Loans II

- Total coupon payments at time $t+T$ is:

$$ P_{t+T} = (1 - \delta) I_t + (1 - \delta) I_t \delta + (1 - \delta) I_t \delta^2 + \ldots + (1 - \delta) I_t \delta^T $$

so,

$$ \lim_{T \to \infty} P_{t+T} = I_t $$

- Recursively, the bank loans can at date $t+1$ equal:

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

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  ◦ Cannot be sold.
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- Recursively, the bank loans can at date $t+1$ equal:

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

- Loan is illiquid.
  - Cannot be sold.

- Repayed with reserves.
  - Implicit operation.
Model - Loans III

- \( I_t \) loans granted at price \( q_t^l \) in deposits
Model - Loans III

- $I_t$ loans granted at price $q^l_t$ in deposits

- Accounting profit on loan: $1 - q^l_t$
  
  - Downward (weakly) sloping curve
  
  - $I_t = \bar{\mu} G (q^l_t)$,
Model - Reserves

- At aggregate determined by FED
Model - Reserves

- At aggregate determined by FED

- Transferred across banks
  - Loan repayment
  - Loan withdrawal
  - Interbank borrowing $\varphi_t$
Deposits

• \( \omega \in [0, \infty) \) may be randomly
  \( \circ \ \omega \sim F(\omega) \)
• Withdrawal payed in reserves
• Withdrawal at balancing stage
Deposits

- $\omega \in [0, \infty)$ may be randomly
  - $\omega \sim F(\omega)$
- Withdrawal payed in reserves
- Withdrawal at balancing stage
- Reserve requirements $\rho \in [0, 1]$.
- Penalty $\chi \cdot (\rho D_t - C_t)^+$ payed increased liabilities.
  - $\chi$ policy parameter: discount rate, fed-funds.
  - Afonso and Lagos (2012).
Model - Income Statement

- Profits realized during the lending stage.
- Dividends $div_t$ payed out in checks
- Dividends subject to capital requirement
  - Prevents Ponzi-scheme
Model - Markets

- **Partial Equilibrium I** here, *individual* bank facing random shocks, \( r \) given
- **Partial Equilibrium II** Market clearing for \( \varphi \) and \( \omega D \).
- **GE** Demand for credit, supply of loans. Goods Market.
Model - Timing:

1. Bank enters period with state \((C_t, B_t, D_t)\)
2. Aggregate state \(X_t\) known:
   - Distribution of individual states (observable)
   - Monetary Policy variables (parameters)
   - Real economic activity (parameter)
3. **Lending stage:** Given \((C_t, B_t, D_t)\) and \(X_t\), bank choose \((b_t, d_t, \varphi_t)\)
4. Coupon payments accrue
5. **Cash-balancing stage:** \(\omega\) – withdrawals
6. Banks pay penalty if illiquid
Value Function - Lending Stage

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

\[ \tilde{D} = D + q(I)I + \text{div} + \varphi(1 + r) \]

\[ \tilde{C} = C + \varphi - B(1 - \delta) \]

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

\[ \tilde{D} \leq \kappa(B + \tilde{C} - \tilde{D}) \]
Value Function - Lending Stage

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Value Function - Lending Stage

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

\[ \tilde{D} = D + q(I)I + d + \left( \tilde{C} - C + B(1 - \delta) \right) (1 + r) \]

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

\[ \tilde{D} \leq \kappa(B + \tilde{C} - \tilde{D}) \]
Value Function - Balancing Stage

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

subject to

\[ C' = C - \omega D \]
\[ D' = D - \omega D + \chi (\rho D (1 - \omega) - C')^+ \]
\[ B' = B \]
Bank Bellman Equation

\[ V^l(C, B, D) = \max_{I,d,\tilde{C}} \left[ u(d) + \beta E_{\omega'} [V^l(\tilde{C} - \omega' \tilde{D}, \tilde{B}, \tilde{D}(1 - \omega') + \chi'(\rho \tilde{D} - (\tilde{C} - \omega' \tilde{D}))] \right] \]

\[ \tilde{D} = D + q(I)I + d + (\tilde{C} - C - B(1 - \delta))(1 + r) \]

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

\[ \tilde{D} \leq \kappa(B + \tilde{C} - \tilde{D}) \]
Properties

• D - Scale Independence
  ○ Leverage Ratio $b = \frac{B}{D}$
  ○ Liquidity Ratio $c = \frac{C}{D}$

• Growth Independence
  ○ $\Delta_D$ independent of D
  ○ Calibration using power law
Bank Bellman Equation

**PROPOSITION:** Value function is homogeneous

\[ V^b (C, D, B; X) = v^b (c, l; X) D^{1-\gamma} \]

\[ v^b (c, e; X) \text{ solves:} \]

\[ v^b (c, b; X') = \max_{I, \text{div,} \varphi} \ U (d) + \beta \int_\Omega \left[ v^b (c', b'; X') U (\Delta_D) |X \right] d\omega \]

subject to same constraints with D=1, and \( \Delta_D \).
Exercise

• Case with $\delta = 1$
• Total Assets cash at beginning
• Policy functions change with higher discount rates?
Next Period Loans

Current Loans

Next Period Loans

Low Interbank Market Rate
Current Loans

Liquidity Ratio

Low Interbank Market Rate
High Interbank Market Rate
value function

Current Loans

Low Interbank Market Rate

Bianchi and Bigio
Liquidity and Money
value function

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Current Loans

\begin{align*}
\text{Low Interbank Market Rate} \\
\text{High Interbank Market Rate}
\end{align*}

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Liquidity and Money
Current Loans

Dividends

Low Interbank Market Rate
Dividends

- Low Interbank Market Rate
- High Interbank Market Rate

Current Loans

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Liquidity and Money
Wrapping Up

- Connect with earlier discussion
- Model will deliver state dependent impact of MP
  - Depending on (c,b) ratios and $\delta$
Wrapping Up

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- Model will deliver state dependent impact of MP
  - Depending on $(c,b)$ ratios and $\delta$
- Model will fail to explain why stimulus ineffective
  - However, additional features may explain this?
Wrapping Up

• Connect with earlier discussion
• Model will deliver state dependent impact of MP
  ◦ Depending on (c,b) ratios and δ
• Model will fail to explain why stimulus ineffective
  ◦ However, additional features may explain this?
• Estimate the model for normal times
• Ask scale of bad shocks
Extensions.

- Cash-hoarding during crisis
  - Bank-run risk
  - Asymmetric information, uncertainty risk
- Loan sales
  - Loan fire sales
  - Liquidity and Solvency Risk COMBINED
- Excessive ex-post regulation
- Weak demand for loans (multiplicity?)
Extensions.

- Cash-hoarding during crisis
  - Bank-run risk
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- Loan sales
  - Loan fire sales
  - Liquidity and Solvency Risk COMBINED

- Excessive ex-post regulation

- Weak demand for loans (multiplicity?)

- Outcomes
  - Banking version of Liquidity Trap? (Frost JPE 1971).
  - Interbank market freezes.