Optimal Banking System for Private Money Creation

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“Money” in Today’s Talk

Money in this paper:

- private money (in real terms)
- created by the private sector in the form of bank deposits, which must be safe assets
- issued via loans to entrepreneurs who hire labor (which generates some future deposits to the system)
  - “Loans create deposits, but indirectly”
Why does System Design Matter?

- Traditional view on bank money creation: **loans create deposits directly**
  - Matching deposits created by loans: “fountain pen money”.
  - Textbook arithmetic: money multiplier = \( \frac{1}{\text{reserve ratio}} \).
  - Only true in a world with no friction.
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• **Friction: loans are illiquid**
  • loans require special payment collecting skills;
  • banks subject to liquidity risks without deposit insurance: *Diamond and Dybvig (1983);*
  • \( \Rightarrow \) **a demand for short-term liquidity** from banks.
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- In a system of more than one bank, the system needs to be well designed to make proper use of this synergy/externality.
This Paper and Post-Crisis Banking Regulation

This Paper:
- Design a banking system under which banks can most effectively create money-like assets (claims on real goods) that are liquid and safe.
- Run proof: Must not be subject to a sunspot panic.

Post-Crisis Banking Regulation (e.g. Basel III)
- Growing concerns of liquidity issues for financial institutions financed with short-term liability;
- Resilience under stress tests on bank liquidity.

Common goal and distinct policy approaches
- Improve banking sector’s ability to weather liquidity/short-term funding stress;
- Basel III: Explicitly tell banks what they should do (LCR, NSFR).
- This paper: Design the structure of banking system such that banks are induced to do the right thing.
Preview of Main Results

Applied theory: Normative and positive

Three market failures

1. An incentive problem (MF 1) ⇒ less money created;
2. A commitment problem (MF 2) ⇒ less money created;
3. A coordination problem (MF 3) ⇒ no money created.

Optimal design of banking system

- Mixed effects of banking competition ⇐ MF 1 v.s. MF 2;
- Role of reserve requirement ⇐ MF 3.

Empirical analysis: An event study

1) 1986 oil bust; 2) staggered banking deregulation in 80s

- For lightly hit areas, deregulation attenuates the shock.
- For heavily hit areas, deregulation amplifies the shock.
Related Literature

- **Banks as money creator**: Diamond and Dybvig (1983); Gorton and Pennachi (1990); Stein (2012); Hart and Zingales (2014); Diamond (2018).

- **Synergies in Bank Activities**: Kashyap, Rajan and Stein (2002).

- **Pecuniary externalities in incomplete markets/contracts**: Geanakoplos and Polemarchakis (1985); Greenwald and Stiglitz (1986); Davila and Korinek (2015).
  - “Collateral” externality: Kiyotaki and Moore (1997); Lorenzoni (2008); Stein (2012); He and Krishnamurthy (2012); Korinek and Simsek (2016).

- **Real effects of banking deregulation**: Kroszner and Strahan (1996); Black and Strahan (2002).
Outline

- A Model of Bank Money Creation
- Efficiency Analysis and Policy Implications
- Empirical Analysis: An Event Study
A Model of Bank Money Creation
The economy is located on a circle as in Salop (1979) and Zentefis (2018).

Three groups of agents:

- $N$ identical banks, each possesses a territory;
- infinitesimal households $(A, B)$ who supply deposits, uniformly scattered with unit mass on each bank's territory;
- one entrepreneur on each bank's territory.
For household $i$, depositing with bank 1 incurs no traveling cost, whereas incurs a cost of $\kappa \cdot L$ if depositing with bank 2.

Parameter $\kappa$: segmentation of retail deposit market;
Parameter $\tau = \frac{1}{\kappa}$: competitiveness of banking market.

$\tau = \infty$: perfectly competitive; $\tau = 0$: completely segmented.
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$\tau = \infty$: perfectly competitive; $\tau = 0$: completely segmented.
Endowments and Technologies

- Three dates: \( T = 0, 1, 2. \)

**Households**
- A: endowment \((1, 0, 0)\), no storage technology;
- B: endowment \((0, e + n, 0)\), storage technology \( h(\cdot) \).

**Entrepreneurs**
- No internal equity, can only be financed by local banks;
- Constant return \( R > 1 \), labor cost \( w \) per unit of production distributed evenly to local household B.

**Banks**
- Hoarding technology of return 1;
- Loans are **illiquid**: cannot be sold to others but can be borrowed against;
- Loans can be liquidated to generate proceeds of \( g(t) \). *(Diamond and Rajan (2005))*
Endogenous Money Creation and Bank Illiquidity

Endowments and technologies:  
- Households
- Banks
- Entrepreneurs

Motivation Model Efficiency and Policy Analysis Empirical Analysis

Endogenous Money Creation and Bank Illiquidity

Endowments and technologies:
Liquidity Shocks on Date 1

- On date 1, depositors (member A) of \( k \) banks see a sunspot: \( \omega = (\omega_1, \ldots, \omega_k) \).
- Realization of \( \omega \) is
  - not known on date 0;
  - observable but not verifiable.
- **Proof to panic**: each bank \( i \in \omega \) must assure its depositors (member A) that running is not self-fulfilling.

Alternative interpretation:

- On date 1, \( k \) banks are picked to be examined: \( \omega = (\omega_1, \ldots, \omega_k) \).
- **Resilience under liquidity stress**: each bank \( i \in \omega \) needs to be able to raise 1 unit of liquidity on date 1.

**Number \( k \):**

- common knowledge to everyone;
- determined by economy’s characteristics: industry structure, risk factor loading, exposure to global cycle...
Bank $i$’s ($i \in \omega$) Liquidity Coverage on Date 1

Liquidity coverage condition:

$$g(t_i, \alpha_i) + s_i(r_i, \cdot) + \sum_{j \in \omega^c} q_{i,j} = \alpha_i$$

Solvency under liquidity shock:

$$S_i(\cdot, \omega) = R(\alpha_i - t_i) - r_i \cdot s_i(r_i, \cdot) - \sum_{j \in \omega^c} r_{i,j} \cdot q_{i,j}$$
Banks’ Problem: A Sequential Game Play

- Date 1: banks play a subgame of liquidity raising after ω hits.
- Date 0: banks play a simultaneous-move game in making loans/creating money.
How Money is Created

- Given strategies $\{\alpha_n\}_{-i}$ of others on date 0, date-1 solvency $S(\alpha_i; \{\alpha_n\}_{-i}, \omega)$ of bank $i$ under $\omega$ as a function of $\alpha_i$:

$$S \equiv \begin{cases} 
\epsilon > 0 & \text{if } i \notin \omega \\
R(\alpha_i - t_i) - r_i \cdot s_i(r_i; \cdot) - \sum_{j \in \omega^c} r_{i,j} \cdot q_{i,j} & \text{if } i \in \omega
\end{cases}$$

where $t_i$, $\{r_n\}$ and $\{(q_{i,j}, r_{i,j})\}$ are equilibrium outcomes of the subgame given $\{\alpha_n\}$ and $\omega$. 
How Money is Created

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\end{cases}
\]

where \( t_i, \{r_n\} \) and \( \{(q_{i,j}, r_{i,j})\} \) are equilibrium outcomes of the subgame given \( \{\alpha_n\} \) and \( \omega \).

- At date 0, taking others’ actions \( \{\alpha_n\}_{-i} \) as given, each bank \( i \) chooses \( \alpha_i \) to solve

\[
\max_{\alpha_i \in [0,1]} R \alpha_i + (1 - \alpha_i)
\]

subject to the money/safe asset creation constraint:

\[
\min_{\omega \in \Omega_k} S (\alpha_i; \{\alpha_n\}_{-i}, \omega) \geq 0
\]
Efficiency Analysis and Policy Implications
Constrained Efficient Benchmark: Planner’s Problem

**Planner’s objective**

*Maximizing the amount of illiquid lending, while guaranteeing the money-like feature of deposits issued by each bank.*
Constrained Efficient Benchmark: Planner’s Problem

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**What planner can choose**

- the lending \( \{\alpha_i\}^{N}_{i=1} \) of all banks on date 0;
- the liquidity raising strategy \( \{t_i, d_i\}_{i \in \omega}, \{d_j\}_{j \in \omega^c} \) on date 1 contingent on the realization of liquidity shock \( \omega \);
- The inter-bank trading deal \( \{q_{i,j}\}_{i \in \omega, j \in \omega^c} \) on date 1.
### Constrained Efficient Benchmark: Planner’s Problem

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- **The inter-bank trading deal** \( \{q_{i,j}\}_{i \in \omega, j \in \omega^c} \) on date 1.

#### What planner needs to respect

- **The outside option of depositors on date 1;**
- **Liquidity surplus banks** \( j \in \omega^c \) do not suffer losses on date 1.
Constrained Efficient Benchmark: Planner’s Problem

- On date 1, after a shock $\omega$ hits, the planner solves

$$L(\{\alpha_n\}, \omega) = \max_{\{t_i\}_{i \in \omega}, \{r_n\}} \sum_{i \in \omega} g(t_i, \alpha_i) + \sum_{n=1}^{N} d(r_n; \alpha_n)$$

subject to the feasibility constraint

$$\sum_{i \in \omega} R \cdot (\alpha_i - t_i) \geq \sum_{n=1}^{N} r_n \cdot d(r_n; \alpha_n)$$

payoff from unliquidated loans

total promised payment
Constrained Efficient Benchmark: Planner’s Problem

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- payoff from unliquidated loans
total promised payment

- On date 0, the planner chooses optimal lending profile according to

$$\{\alpha_n^P\} = \arg \max_{\{\alpha_n\}} \sum_{n=1}^{N} \alpha_n$$

subject to the safe asset creation constraint at system level:

$$\min_{\omega \in \Omega_k} \left. L \left( \{\alpha_n\} , \omega \right) \right|_{\{\alpha_n\}} - \sum_{i \in \omega} \alpha_i \geq 0$$

maximum of date-1 liquidity
demand for date-1 liquidity
Graphic Illustration: Planner’s Problem

- Social planner
  - $\alpha$
  - $1 - \alpha$

- Banking sector
  - Illiquid lending
  - Liquid assets
  - Illiquid lending
  - Liquid assets
  - Illiquid lending
  - Liquid assets

- Ex-ante creation
- Ex-post usage

- Liquidity pool
Two Trade-offs in Planner’s Solution

Trade-off 1: Ex-ante (date-0) creation of the liquidity pool

\[
\min_{\omega \in \Omega_k} L(\{\alpha_n\}, \omega) = \sum_{i \in \omega} \alpha_i
\]

- LHS > RHS meaning pool being under-produced.

Trade-off 2: Ex-post (date-1) usage of the liquidity pool

\[
d(r^*; \alpha P) \cdot \Delta d'(r^*; \alpha P) = R \cdot \Delta g(t^*, \alpha P)
\]

- price increase + \(r^* \cdot \Delta \) volume increase = reduction in liquidation • LHS: marginal cost of raising \(\Delta\) more unit of liquidity from the pool;
  - RHS: marginal benefit of reducing liquidation by \(\Delta/g'(t^*)\).
Motivation Model Efficiency and Policy Analysis Empirical Analysis

Two Trade-offs in Planner’s Solution

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Trade-off 2: Ex-post (date-1) usage of the liquidity pool

\[
d(r^*; \alpha_P) \cdot \frac{\Delta}{d'(r^*; \alpha_P)} + r^* \cdot \frac{\Delta}{\text{volume increase}} = R \cdot \frac{\Delta}{\partial g(t^*, \alpha_P)} \left/ \partial t \right. 
\]

- LHS: marginal cost of raising \( \Delta \) more unit of liquidity from the pool;
- RHS: marginal benefit of reducing liquidation by \( \Delta/g'(t) \).
Can this Benchmark be Decentralized?

The constrained efficient benchmark hinges on the following:

On date 1

- Surplus liquidity in the economy can be frictionlessly reallocated within the banking system;
- The optimal liquidity raising strategy \( \{ t_i^{SP}, d_i^{SP} \}_{i \in \omega} \) in planner's solution can be committed.

On date 0

- The lending profile \( \{ \alpha_i^{SP} \}_{i=1}^N \) can be coordinated.
Can this Benchmark be Decentralized?

The constrained efficient benchmark hinges on the following:

**On date 1**
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**Three market failures** may prevent the implementation of the efficient benchmark in a decentralized economy.
Can this Benchmark be Decentralized?

The constrained efficient benchmark hinges on the following:

**On date 1**
- Surplus liquidity in the economy can be **frictionlessly** reallocated within the banking system; ⇐ Market failure 1
- The optimal liquidity raising strategy \( \{ t^S_{i}, d^S_{i} \}_{i \in \omega} \) in planner’s solution can be committed. ⇐ Market failure 2

**On date 0**
- The lending profile \( \{ \alpha^S_{i} \}_{i=1}^{N} \) can be **coordinated**. ⇐ Market failure 3

**Three market failures** may prevent the implementation of the efficient benchmark in a decentralized economy.
Example: $N = 2$, $k = 1$, $\tau = 0$.

With $\tau = 0$, we can show $q_{1,2} < s(r_{1,2}; \alpha)$. $\Rightarrow$ Bank 1 is being held up in interbank trading.
# Market Failure 1: Efficiency Analysis

<table>
<thead>
<tr>
<th>Liquidity coverage:</th>
<th><strong>Equilibrium</strong></th>
<th><strong>Planner’s problem</strong></th>
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<td>( \alpha_E ) is the maximum ( \alpha ) such that</td>
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<td>Inter-bank liquidity pricing:</td>
<td>((q_{1,2}, r_{1,2}) = \arg\max_{q_{1,2}, r_{1,2}} [V_1(q_{1,2}, r_{1,2})]^\beta [V_2(q_{1,2}, r_{1,2}) - V_2^R]^{1-\beta} )</td>
<td>( q_{1,2} = s(r_{1,2}, \alpha) ) with mark-up</td>
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<td>Solvency:</td>
<td>( R(\alpha - t_1) - [r_1 s(r_1; \alpha) + r_{1,2} q_{1,2}] \geq 0 )</td>
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Proposition 1

For $k \leq N - 1$, the laissez-faire equilibrium of bank money creation is inefficient (that is, $\alpha^E < \alpha^P$), whenever $\tau < \infty$. 
Market Failure 1: A Missing Futures Market

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For $k \leq N - 1$, the laissez-faire equilibrium of bank money creation is inefficient (that is, $\alpha^E < \alpha^P$), whenever $\tau < \infty$.

- A positive (“collateral”) externality: each bank’s date-0 lending enlarges the ex-post liquidity pool; [Literature]
- Missing an ex-ante futures market that allows banks to purchase date 1 liquidity at pre-specified price.
  - liquidity shocks observable but not verifiable;
  - moral hazard issues.
- Inefficient incentive provision $\Rightarrow$ Ex-ante under-production of common liquidity pool.
- Relevant when economy is subject to idiosyncratic shocks.
Solution to MF1: Opening an Ex-post Spot Market

Corollary 1

For $k = 1$, the laissez-faire equilibrium of bank money creation is efficient (that is, $\alpha^E = \alpha^P$), if $\tau = \infty$.

- An ex-post spot market, which allows banks raise deposits from outside HH, can restore efficient incentives;
- Improves threat point in bargaining for banks get hit.
Corollary 1

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- An ex-post spot market, which allows banks raise deposits from outside HH, can restore efficient incentives;
- Improves threat point in bargaining for banks get hit.

Policy Implication

If an economy is subject to idiosyncratic risks (small $k$, e.g. has a diversified industry structure), a competitive banking system helps.

- The ex-post spot market can achieve better risk-sharing when idiosyncratic shocks hit.
Empirical Predictions: Resilience to Idiosyncratic Shocks

Lending Dynamics in Non-oil States after the Oil Shock

For non-oil states, the C&I lending of the hit banks will be more resilient in states where deregulation has been implemented when the oil shock hits.
Market Failure 2: Example

**Example**: \( N = 2, \ k = 2, \ \tau = \infty \).

With \( \tau = \infty \), we can show \( (t_1^E, r_1^E) \neq (t^*, r^*) \).

Detailed analysis
Market Failure 2: Numerical example

- Numerical specifications:
  - Individual deposit supply: \( r(d) = d \)
  - Cost of liquidation: \( R \cdot g(-1)(t) = t^2 \).

- When separated, each bank solves the following cost minimization problem:

\[
C \equiv \min_{d,t} d \cdot r(d) + t^2
\]

subject to

\[
d + t = 1
\]

- \((d^*, t^*) = (0.5, 0.5)\), liquidity price \( r^* = 0.5 \)
- \( C(d^*, t^*) = 0.5 \cdot 0.5 + 0.5^2 = 0.5 \)
Market Failure 2: Numerical example (Cont’d)

- When combined, \((d^*, t^*)\) can no longer be committed.
  - If bank 1 sticks to \((0.5, 0.5)\), bank 2 could offer a price \(\hat{r} = 0.51\).
  - This allows it raise any amount of deposits in range \([0.51 \times 1, 0.51 \times 2]\). Let’s pick \(\hat{d} = 0.51 \times 1.5 = 0.765\).
  - Still need \(\hat{t} = 1 - 0.765 = 0.235\) from liquidation.
  - In this way, total cost is reduced to

\[
C(\hat{d}, \hat{t}) = \hat{d} \cdot \hat{r} + \hat{t}^2 = 0.765 \times 0.51 + 0.235^2 = 0.445
\]
Market Failure 2: Numerical example (Cont’d)

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\]

- Instead, equilibrium liquidity price \(r_E\) has to go up to \(r_E = \frac{2}{3}\) to ensure no stealing. Accordingly, \((d_E, t_E) = (\frac{2}{3}, \frac{1}{3})\).
  - Stealing deterrence: \((t_E^2)’ = 2 \times t_E = r_E\).
  - As such, total cost is

\[
C (d_E, t_E) = d_E \cdot r_E + t_E^2 = \frac{2}{3} \times \frac{2}{3} + \left(\frac{1}{3}\right)^2 = 0.556
\]
## Market Failure 2: Efficiency Analysis

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<td>Incentive constraint:</td>
<td>$-R + \hat{r} \cdot \frac{\partial g(t, \alpha)}{\partial t} = 0$</td>
<td>sub-optimal liquidity raising</td>
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<td>Solvency:</td>
<td>$R(\alpha - t) - r \cdot d(\hat{r}; \alpha) \geq 0$</td>
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Proposition 2

For $k \geq 2$, the laissez-faire equilibrium of bank money creation is inefficient (that is, $\alpha^E < \alpha^P$), whenever $\tau > 0$. 
Market Failure 2: A Welfare-reducing Spot Market

Proposition 2
For $k \geq 2$, the laissez-faire equilibrium of bank money creation is inefficient (that is, $\alpha^E < \alpha^P$), whenever $\tau > 0$.

- A negative ("distributive") externality: A bank posts a rate in others’ territory drives up the liquidity price for others; 

- When $\tau > 0$, an ex-post spot market emerges and reduces welfare: reminiscent of Hart (1975);

- The presence of this spot market forces banks to adopt sub-optimal strategies: ex-post over-usage of common liquidity pool.

- Relevant when economy is subject to systemic shocks.
Solution to MF2: Shutting Down this Spot Market

Corollary 2

For $k = N$, the laissez-faire equilibrium of bank money creation is efficient (that is, $\alpha^E = \alpha^P$), if $\tau = 0$.

- Shutting down this spot market can discipline the potential liquidity stealing behavior.
- This allows banks to deploy the liquidity-raising strategies they “truly wish” to deploy.
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For \( k = N \), the laissez-faire equilibrium of bank money creation is efficient (that is, \( \alpha^E = \alpha^P \)), if \( \tau = 0 \).

- Shutting down this spot market can discipline the potential liquidity stealing behavior.
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Policy Implication

*If an economy is subject to systemic risks (large \( k \), e.g. has a concentrated industry structure), a competitive banking system hurts.*

- The ex-post spot market may trap the economy into a high interest rate equilibrium when systemic shocks hit.
Lending Dynamics in Oil States after the Oil Shock

For oil states, the C&I lending of the hit banks will contract more in states where deregulation has been implemented when the oil shock hits.
Summary so far: Mixed Effects of Banking Competition

• Given all banks choose $\alpha$ on date 0, it requires:

$$\min_{\omega \in \Omega_k} S(\alpha; \{\alpha\}_{-i}, \omega) \geq 0$$

$S(\cdot; \omega)$ evaluated with equilibrium outcomes on date 1.

• Both market failures I and II would make this constraint inefficiently tight $\Rightarrow$ equilibrium $\alpha_E$ inefficiently small.

• Competitive banking market $\Leftrightarrow$ an ex-post spot market
  • Higher competition $\tau$ alleviates market failure I: Incentivizing tool;
  • Lower competition $\tau$ alleviates market failure II: Disciplining tool.

• Yet, there is another problem...
Market Failure 3: A Coordination Problem on Date 0

- If all banks choose $\alpha_E$ at date 0, where

$$\min_{\omega \in \Omega_k} S(\{\alpha_E\}; \omega) \geq 0$$

then deposits of all banks can be guaranteed money-like.

- Define $S_D(\alpha; \alpha_E)$ as the individual deviation function where
  - all other banks choose $\alpha_E$
  - an individual bank deviates to choose an arbitrary $\alpha$
  - $S_D(\alpha; \alpha_E)$: perceived solvency after deviation.

- A bank can commit to choosing $\alpha_E$ given others doing so iff

$$\frac{\partial S_D(\alpha; \alpha_E)}{\partial \alpha} |_{\alpha \rightarrow \alpha_E^+} < 0$$

- Coordination failure when banks cannot commit.
Example: $N = k = 10^6$

1) $\alpha_E(0)$: Solvent and can be coordinated
2) $\alpha_E(\infty)$: Solvent but cannot be coordinated
3) $\hat{\alpha}$: Insolvent

Motivation  Model  Efficiency and Policy Analysis  Empirical Analysis
Proposition 3

For each \((N, k)\), there exists a threshold \(\tau_{AI}\) in retail market competitiveness \(\tau\), such that the symmetric bank money creation equilibrium \(\{\alpha_E\}\) can be coordinated if and only if \(\tau \leq \tau_{AI}\).

Intuition

When making ex-ante deviation becomes less expensive due to more competitive ex-post market, banks may not be able to commit to the ex-ante strategy that guarantees the ex-post solvency of the whole system.
When banking market is competitive, a uniform reserve requirement becomes necessary for bank money creation.

To implement the optimal equilibrium, a regulator

- can **deregulate** the banking market to $\tau = \tau^*$
- paired with a **reserve requirement** $1 - \alpha \geq 1 - \alpha_E(\tau^*)$. 

**Policy Implication**
Empirical Analysis: An Event Study
Natural experiment: 1986-87 oil price shock

- States were affected differently by the oil price shock;
- Staggered banking deregulation: within the most heavily hit states, some were deregulated while others are not.

Ideal environment to test: how interaction b.t.w local banking sector competitiveness and the scope of liquidity shock affect:

- Liquidity raising price: wholesale funding cost and retail funding cost;
- Bank C&I Lending behavior.
The 1986 oil-price shock

The above figure shows the time-varying pattern of oil shock’s impact on oil and gas firms’ balance sheet conditions. Retained earnings is defined as the Retained Earnings (req) scaled by lagged assets; and Operating Income is defined as Operating Income Before Depreciation (oibdpq) scaled by lagged assets.
State level C&I Lending dynamics
3-digit zip code areas where banks are exposed oil shocks and the location of oil firms

Defining systemically exposed area: banks in a 3-digit zip code area is defined as systemically exposed if the (weighted) average of the areas banks’ past-due loans (within 3 months) as a share of assets went up by more than 3.35%.

Mathematically: \[ \text{Ave.} \left( \frac{\text{within 3-month overdue}}{\text{Total assets}} \right)_{86-87} - \text{Ave.} \left( \frac{\text{within 3-month overdue}}{\text{Total assets}} \right)_{85} > 3.35\% . \]
Treatment effect of oil price shock on bank lending in different areas

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Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

$$y_{b,z,q} = \alpha_i + \gamma_{z,q} + \beta_1 1[\text{Post}] + \beta_2 1[\text{Deregulated}] \times 1[\text{Post}] + \beta_3 X + \text{FEs} + \epsilon_{b,z,q}$$
3-digit zip C&I lending dynamics

Motivation Model Efficiency and Policy Analysis Empirical Analysis

\[ y_{b,z,t} = \alpha_i + \gamma_{z,q} + \sum_{t=1982, t \neq 1985}^{t=1990} \beta_t 1[\text{Year}=t] + \beta_3 X + FE + \epsilon_{b,z,t} \]
Wholesale interest expenses and scale of shocks

\[ \ln(\text{wholesale int. expense})_{\text{Dereg.}/\text{Undereg.}} = \alpha_i + \gamma z_q + \sum_{t=1990}^{t=1990} \beta_t 1[\text{Year}=t] + \beta_3 X + FE_s + \epsilon_{b,z,q} \]
Retail interest expenses and scale of shocks

\[
\text{Ln(Retail int. expense)}_{b,z,q}^{\text{Dereg./Undereg.}} = \alpha_i + \gamma_{z,q} + \sum_{t=1982, t\neq 1985}^{t=1990} \beta_t 1[\text{Year}=t] + \beta_3 X + \text{FEs} + \epsilon_{b,z,q}
\]
## Treatment effect on retail price

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<td>* $p &lt; 0.05$, ** $p &lt; 0.01$, *** $p &lt; 0.001$</td>
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Retail rate$_{b,z,q} = \alpha_i + \gamma_{z,q} + \beta_1 1[\text{Post}] + \beta_2 1[\text{Deregulated}] \times 1[\text{Post}] + \beta_3 X + FEs + \epsilon_{b,z,q}$
Retail rate changes and scale of shocks

\[
\text{Retail rate}_{\text{Dereg.} / \text{Undereg.}} = \alpha_i + \gamma_{z,q} + \sum_{t=1982, t \neq 1985}^{t=1990} \beta_t 1[\text{Year} = t] + \beta_3 X + FEs + \epsilon_{b,z,t}
\]
Treatment effect on wholesale price

\[
\text{wholesale rate}_{b,z,q} = \alpha_i + \gamma_{z,q} + \beta_1 [\text{Post}] + \beta_2 [\text{Deregulated}] \times [\text{Post}] + \beta_3 X + FEs + \epsilon_{b,z,q}
\]

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<tr>
<td>* p &lt; 0.05, ** p &lt; 0.01, *** p &lt; 0.001</td>
<td></td>
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</table>
Wholesale rate changes and scale of shocks

\[
\text{wholesale rate}_{b,z,q}^{\text{Dereg./Undereg.}} = \alpha_i + \gamma_{z,q} + \sum_{t=1982, t \neq 1985}^{t=1990} \beta_t 1[\text{Year}=t] + \beta_3 X + FEs + \epsilon_{b,z,t}
\]
Conclusion

• A framework of bank money creation, in which the **price of short-term liquidity** plays a critical role.

• **Three market failures** could result in inefficiency in the private money creation in a decentralized economy.

• Policy implications:
  
  • competitive banking market can help achieve **better risk sharing** when the system hit by **idiosyncratic** shocks;
  
  • competitive banking market may trap the economy into a **high interest rate** equilibrium when the system hit by **systemic** shocks;
  
  • when banking market is sufficiently competitive, a **reserve requirement** becomes necessary.
Appendix
Illustration of “Fountain Pen Money”

After a loan is made and before it pays off:
Fact I: Banking Deregulation and Monetary Control

Depository Institutions Deregulation and Monetary Control Act of 1980

Synchronized enforcement of reserve requirements with the banking deregulation.
Fact II: The 1986 oil-price shock

The above figure shows the time-varying pattern of oil shock’s impact on oil and gas firms’ balance sheet conditions. Retained earnings is defined as the Retained Earnings (req) scaled by lagged assets; and Operating Income is defined as Operating Income Before Depreciation (oibdpq) scaled by lagged assets.
Fact II: Mixed Effects of Banking Deregulation

Notes: The figure plots the dynamics of average bank C&I lending dynamics of banks in Oil states and Non-Oil states. Each dot represents the weighted average of C&I lending of banks in the states. Oil states include Texas, Oklahoma, Louisiana, New Mexico, California, North Dakota, Utah, Alaska, Wyoming and non-oil states include all other states that contains at least one three-digit zip code are that is defined as exposed to shocks.
Fact II: Mixed Effects of Banking Deregulation

Notes: The figure plots the dynamics of average bank C&I lending dynamics of banks in Oil states and Non-Oil states. Each dot represents the weighted average of C&I lending of banks in the states. Systemic shock states include Texas, Oklahoma, Louisiana, New Mexico, and Arkansas, and Idiosyncratic shock states include all other states that contain at least one three-digit zip code that is defined as exposed to shocks.
At date 0, member A has to rely on banks for value storage.

Before date 1, member B receives endogenous labor income \( n \).

Storage technology \( h(y) \) allows B to transfer value from date 1 to date 2: \( h'(y) > 0, \ h''(0) < 0. \)
Motivation

Model

Efficiency and Policy Analysis

Empirical Analysis

Endowments and Technologies: Entrepreneurs

- No internal equity, all externally financed by local banks.
- Linear production technology with return $R > 1$ and no risk in project return.
- Requires labor cost $w \in (0, 1)$ per unit of production, evenly distributed to local households before date 1.
At date 0, after receiving 1 unit of deposits, each bank
- invest $\alpha$ to finance entrepreneur’s production;
- keep $1 - \alpha$ in a liquid but low return asset (cash).

Choice of $\alpha$ unobservable at date 0, but revealed to others before date 1.

Liquidation technology $g(t, \alpha) < R \cdot t$ satisfies
i) $\frac{\partial g(t, \alpha)}{\partial t} > 0$;
ii) $\frac{\partial^2 g(t, \alpha)}{\partial t^2} < 0$;
iii) $\frac{\partial g(t, \alpha)}{\partial \alpha} < 0$. 
Price of Retail Liquidity: Households’ Problem

- HH member B’s endowments at date 1 ⇔ deposit base
- For a B with endowments $e + w \cdot \alpha$, it’s inverse deposit supply is $r(d; \alpha) \equiv h'(e + w \cdot \alpha - d)$
  ⇒ Individual deposit supply: $d(r; \alpha) = r^{-1}(d; \alpha)$
  ⇒ aggregate deposit supply function $s_i(r_i; \cdot)$ for each bank $i$. 
Price of Retail Liquidity: Households’ Problem

- HH member B’s endowments at date 1 ⇔ deposit base
- For a B with endowments $e + w \cdot \alpha$, it’s inverse deposit supply is $r(d; \alpha) \equiv h'(e + w \cdot \alpha - d)$
  $\Rightarrow$ Individual deposit supply: $d(r; \alpha) = r^{-1}(d; \alpha)$
  $\Rightarrow$ aggregate deposit supply function $s_i(r_i; \cdot)$ for each bank $i$.

Examples:
- If $\tau = 0$, for a bank $i$ who chose $\alpha_i$ at date 0
  $$s_i(r_i; \alpha_i) = d(r_i; \alpha_i)$$
- If $\tau = \infty$ and all other banks $n \neq i$ posting rate $\bar{r}$,
  $$s_i(r_i; \bar{r}) = \begin{cases} 
  0 & r_i < \bar{r} \\
  \text{anything} & r_i \geq \bar{r}
  \end{cases}$$

Higher $\tau \Rightarrow$ More elastic deposit supply $s_i(r_i; \cdot)$ given others’ action; but also more susceptible to others’ action.
Price of Wholesale Liquidity: Interbank Bargaining

- **Non-cooperative bargaining** between each liquidity-needy bank $i \in \omega$ and each surplus bank $j \in \omega^c$.
- **Friction**: No free access to discount window facilities.
- Trading deal $(q_{i,j}, r_{i,j})$ determined as Nash bargaining solution.

\[ \tau \text{ determines supply elasticity} \]
Market Failure 1: Example

- Example: $N = 2$, $k = 1$, $\tau = 0$.
- Symmetric equilibrium, i.e., all banks choose $\alpha$ at date 0.
- WOLG, suppose bank 1 is subject to liquidity shock at date 1, which then
  - liquidates $t_1$ of its long-term asset
  - posts a rate $r_1$ in retail deposit market
  - borrows from bank 2 for $q_{1,2}$ at rate $r_{1,2}$.
- In this case, the deposit supply function for each bank $i$ is
  \[ s(r_i; \alpha) = d(r_i; \alpha) \]
  Each bank can only raise deposits in its own territory.
Market Failure 1: Example Analysis

- Bank 1’s Liquidity coverage condition: \( g(t_1, \alpha) + s(r_1; \alpha) + q_{1,2} = \alpha \)

- Interbank trading deal \((q_{1,2}, r_{1,2})\) determined by:

\[
(q_{1,2}, r_{1,2}) = \arg \max_{\hat{q}_{1,2}, \hat{r}_{1,2}} \left[ V_1(\hat{q}_{1,2}, \hat{r}_{1,2}) - V_1^R \right]^\beta \left[ V_2(\hat{q}_{1,2}, \hat{r}_{1,2}) - V_2^R \right]^{1-\beta}
\]

where

- \(\beta\): exogenous bargaining power parameter,
- \(V_i^R\): bank \(i\)'s reservation value from outside option
- \(V_i(\hat{q}_{1,2}, \hat{r}_{1,2})\): bank \(i\)'s valuation of any arbitrary deal \((\hat{q}_{1,2}, \hat{r}_{1,2})\).

- With \(\tau = 0\), we can show \(q_{1,2} < s(r_{1,2}; \alpha)\).
Market Failure 2: Example

- Example: $N = 2$, $k = 2$, $\tau = \infty$.
- Focus on symmetric equilibrium, i.e., all banks choose $\alpha$ at date 0.
- In the equilibrium on date 1, both banks liquidate $t$ of their long-term assets and post a rate $\hat{r}$ in retail deposit market.
- $\tau = \infty$ implies that given the other post $\hat{r}$, each bank
  - can raise nothing by posting any rate $r < \hat{r}$;
  - can raise as much as it wants (bounded by some limit) by posting rate $r \geq \hat{r}$.
- The equilibrium deposit rate $\hat{r}$ must ensure that both banks have no incentive to deviate.
Market Failure 2: Example Analysis

- No incentive to deviate in liquidity raising:

\[-R + \hat{r} \cdot \frac{\partial g(t, \alpha)}{\partial t} = 0\]

- Aggregate deposit market clearing:

\[2 \cdot d(\hat{r}; \alpha) = 2 \cdot [\alpha - g(t, \alpha)]\]

  - At deposit rate $\hat{r}$, the supply of deposits from each individual HH is $d(\hat{r}; \alpha)$;
  - After liquidating $t$, the demand for deposits from each bank is $\alpha - g(t, \alpha)$. 
Part I: A Synergy between Banking Activities
Data Description

Data sources:

- Bank balance sheet: Call report.
- Bank branching: FDIC Databook on Operating Banks and Branches.

Definition of key dependent variables:

- **Retail liquidity price** of a bank is defined as Interest Expense on Deposits scaled by lagged Total Deposits.
- **Wholesale liquidity price** is defined as Interest expense on trading and other borrowed and interest expense on Fed Funds repo liabilities scaled by the lagged trading liabilities and Fed Funds repo liabilities.
- **Liquid asset holding** is defined as the sum of cash, Fed Funds repo assets and trading assets scaled by total assets.
Loans “Create” Deposits

• The credit received by a firm will circulate in the system, be it in the form of labor payment or corporate savings, generating fresh supply of short term liquidity for nearby banks.

Hypothesis for testing:
• If corporations in an area (e.g., a 3-digit zip-code) exogenously receive more credit from banks located in other areas, then banks in this area can subsequently
  • receive more deposit;
  • raise short-term liquidity at a lower price.
Local Credit and Local Deposit Growth

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Standard errors in parentheses
* p < 0.05, ** p < 0.01, *** p < 0.001

Note: Deposit growth is defined as the log change in deposits of a given bank in a given quarter(\(ln(\text{Deposit}_t) – ln(\text{Deposits}_{t−1})\)), ∆Local credit is the log of total new credit generated by banks from other counties to the local county. The regression is based on 9002 banks from 233 3-digit zip-codes.
## Placebo Test I

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Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Deposit growth is defined as the log change in deposits of a given bank in a given quarter ($ln(\text{Deposit}_t) - ln(\text{Deposits}_{t-1})$).
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</table>

Standard errors in parentheses
* \(p < 0.05\), ** \(p < 0.01\), *** \(p < 0.001\)

Note: Deposit growth is defined as the log change in deposits of a given bank in a given quarter (\(ln(\text{Deposit}_t) - ln(\text{Deposits}_{t-1})\)), \(ΔL-I\) sector credit\text{out}_{t-1} is the log of total new credit from outside banks to the local county that flew to the labor intensive sector, similarly for the Non labor-intensive sector. The regression is based on 8572 banks from 215 counties.
## Local Credit and Local Liquidity Price

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<th></th>
<th>Δ Retail rate</th>
<th>Δ Wholesale rate</th>
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<td>ΔLocal credit$^{out}_{t}$</td>
<td>-0.244***</td>
<td>-0.269***</td>
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</table>

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: ΔRetail/Wholesale are the bank-level change in \( \frac{\text{Interest expense on deposits}}{\text{Total deposits}} / \frac{\text{Interest expense on wholesale liabilities}}{\text{Wholesale liabilities}} \), where here wholesale liabilities is focused on "Interest expense on Fed funds purchased and securities sold under agreements to repurchase." In call report they are RCFD3353 and RIAD4180.