Liquidity Regulation and Credit Booms: Theory and Evidence from China

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Introduction

- Major regulatory push after recent financial crisis
- Need a theoretical framework to predict unintended consequences
- We build a framework with three main ingredients:
  - Big and small banks
  - Interbank market for liquidity with endogenous pricing
  - Off-balance-sheet vehicles as a choice variable
- We show that stricter liquidity standards can generate unintended credit booms in this environment
- Application to China:
  - Strong empirical support for model’s cross-sectional predictions
  - Tightening of liquidity rules explains one-third of China’s credit boom from 2008 to 2014
Model Environment

- Notation for bank $j$:
  
  \[
  \begin{align*}
  D_j &= \text{deposits} \\
  W_j &= \text{deposit-like products (DLPs)} \\
  \tau_j &= \text{fraction of DLPs sent off-b/s} \\
  R_j &= \text{reserves}
  \end{align*}
  \]

- Bank’s liabilities:
  
  \[
  D_j + (1 - \tau_j) W_j + \tau_j W_j 
  \]

- Bank’s assets:
  
  \[
  R_j + D_j + (1 - \tau_j) W_j - R_j + \tau_j W_j 
  \]
Model Environment

- Loans are long-term:

  \[
  \begin{align*}
  t = 0 & \quad t = 1 & \quad t = 2 \\
  $1 & \quad \rightarrow & \quad $0 & \quad \rightarrow & \quad $(1 + i_A)^2
  \end{align*}
  \]

- Deposits (storage for now) and DLPs are short-term:

  \[
  \begin{align*}
  t = 0 & \quad t = 1 & \quad t = 2 \\
  $1 & \quad \rightarrow & \quad $1 & \quad \rightarrow & \quad \begin{cases} 
  $1 & \text{if } D_j \\
  $1 + \xi_j & \text{if } W_j
  \end{cases}
  \end{align*}
  \]

- Idiosyncratic withdrawals of deposits and DLPs:
  - With probability \( \pi \), fraction \( \theta_\ell \) withdrawn at \( t = 1 \) (“state \( \ell \)”).
  - With probability \( 1 - \pi \), fraction is \( \theta_h > \theta_\ell \) (“state \( h \)”).
Model Environment

- Loan-to-deposit limit:

\[
D_j + (1 - \tau_j) W_j - R_j \leq (1 - \alpha) \cdot [D_j + (1 - \tau_j) W_j]
\]

on-b/s loans limit on-b/s deposits

Rewrite as liquidity requirement:

\[
\lambda_j \equiv \frac{R_j}{D_j + (1 - \tau_j) W_j} \geq \alpha
\]

- Interbank market for reserves at \( t = 1 \) with interest rate \( i_L \). Includes external liquidity \( \Psi(i_L) \equiv \psi i_L \) where \( \psi > 0 \).

- Household savings normalized so \( \sum_j (D_j + W_j) = X \)
Baseline: Only Small Banks

- Unit mass of ex ante identical small banks
- Each is a price-taker on the interbank market
- At \( t = 0 \), the representative bank chooses \( D_j, W_j, \xi_j, \tau_j, \) and \( R_j \) to maximize expected profit subject to \( \lambda_j \geq \alpha \)
- Objective function:

\[
(1 + i_A)^2 (D_j + W_j - R_j) + (1 + i_L) \left[ R_j - \bar{\theta} (D_j + W_j) \right] 
- (1 - \bar{\theta}) [D_j + (1 + \xi_j) W_j] 
- \frac{\phi}{2} (D_j + W_j)^2
\]

from loans

from surplus/shortage of reserves at \( t=1 \)

final payment to savers at \( t=2 \)

operating cost (for later)
Baseline: Only Small Banks

- Demand functions from a simple household optimization problem with DLP transactions costs:

\[ W_j = \omega \xi_j \]

\[ D_j + W_j = X + \rho (\xi_j - \bar{\xi}) \]

- Each bank takes average DLP returns (\(\bar{\xi}\)) as given

- In symmetric equilibrium, \(\xi_j = \bar{\xi}\) and interbank market clears:

\[ \underbrace{R_j + \psi i_L}_{\text{available liquidity}} = \underbrace{\bar{\theta} X}_{\text{required liquidity}} \]
Baseline: Only Small Banks

- Shadow cost of liquidity rule is \( \mu_j \equiv (1 + i_A)^2 - (1 + i_L) \)

- We get \( \tau_j = 1 \) if \( \alpha \mu_j \xi_j > 0 \), where:

\[
\xi_j = \frac{f(i_L) - \phi(D_j + W_j)}{2(1 - \theta)} \times \frac{\rho}{\omega} + \frac{\alpha \mu_j \tau_j}{2(1 - \theta)}
\]

- Competitive motive for issuing DLPs
- Reg. arbitrage motive

- Consider \( \rho = 0 \) or \( \phi \) high enough so no DLPs at \( \alpha = 0 \) (initial eqlm)

- Proposition:
  1. Increasing \( \alpha \) above some threshold makes \( \tau_j \xi_j \) positive (i.e., get shadow banking as endogenous response to stricter regulation)
  2. But \( i_L \) and credit are highest at low \( \alpha \) (market mechanism at work)
Full Model: Adding a Big Bank

- Big bank \((k)\) internalizes its effect on all endogenous variables

- Allocation of household savings:

\[
D_k + W_k = \delta + \rho_1 (\xi_k - \xi_j)
\]
\[
D_j + W_j = 1 - \delta + \rho_1 (\xi_j - \xi_k) + \rho_2 (\xi_j - \xi_j)
\]

- Small banks take as given \(\xi_k, \bar{\xi}_j\), and interbank rate
In equilibrium, $\xi_j = \bar{\xi}_j$ and no reserve shortage at $t = 1$:

Market clearing when big bank’s withdrawal shock is high:

$$R_j + R_k + \psi i_L^h = \bar{\theta} (D_j + W_j) + \theta_h (D_k + W_k)$$

To simplify, $i_L^h = 0$ when big bank’s withdrawal shock is low.

At $t = 0$, the big bank chooses $\xi_k$, $\tau_k$, and $R_k$ to maximize its expected profit subject to:

1. Liquidity rule $\lambda_k \geq \alpha$
2. Small bank optimality conditions for $\xi_j$, $\tau_j$, and $R_j$
3. $i_L^h$ from interbank market clearing equation
Main Results from Full Model

Under mild parameter conditions:

- Small banks have higher loan-to-deposit ratios than big bank
- Introducing loan-to-deposit cap that binds on only small banks leads to:
  - DLP issuance by both small and big banks
    - Off-balance-sheet issuance dominated by small
    - On-balance-sheet issuance dominated by big
    - Small more aggressive \((\xi_j^* > \xi_k^*)\) so funding share of big falls
  - Higher interbank interest rate
    - Big bank uses price of emergency liquidity to dampen small banks’ incentives to circumvent liquidity rules
- Convergence of on-balance-sheet loan-to-deposit ratios
- Increase in total credit
  - Reallocation of funding from big to small (higher intensity lenders)
  - Shift by big bank from interbank market to traditional loans
China: Aggregate Facts

- China starts raising bank liquidity standards in 2008 via stricter and more frequent enforcement of a 75% loan-to-deposit cap.

- Shadow banking emerges:
  - Define as maturity mismatch ("banking") that doesn’t live on regulated balance sheets ("shadow")
  - In China, short-term funding is raised via unguaranteed WMPs then funneled to trust companies who make longer-term loans
  - Grows from trivial fraction of GDP in 2007 to 16% of GDP by 2014

- Weighted average repo rate rose by 50bps and maximum daily rate rose by 150bps despite increasing monetary injections by PBOC

- Credit-to-savings ratio rose by roughly 10pp with 6pp not attributable to bank-funded fiscal stimulus
China: Cross-Sectional Facts
Shadow banking was driven by small banks

- Big Four vs Small Banks (JSCBs & City/Rural Banks)
- Between 2008 and 2014, small banks:
  - Accounted for 73% of all new WMP batches
  - Issued 57% of their batches without a guarantee (Big Four 46%)
  - Accounted for roughly 64% of unguaranteed WMP balances outstanding at the end of 2013
  - Offered higher WMP returns than big banks
- Granger causality tests: small bank issuance causes big bank issuance but not vice versa
China: Cross-Sectional Facts

Small banks were responding to liquidity rules

**Loan-to-Deposit Ratios**

- Blue line: Big Four
- Red line: Joint-Stock Banks
- Dashed blue line: Using Avg Balances
- Dashed red line: Using Avg Balances

**WMPs Issued by China Merchants Bank**

- Black line: Median Non-Guaranteed Maturity (Days, Left Axis)
- Blue dotted line: Median Guaranteed Maturity (Days, Left Axis)
- Red line: Median Non-Guaranteed Expected Return (% Right Axis)

Notes: Solid lines in left panel use year-end balances. Shaded area is interquartile range of JSCBs.

Sources: Bankscope, Bank Annual Reports, and Wind Financial Terminal
China: Cross-Sectional Facts

Convergence of on-balance-sheet loan-to-deposit ratios

- Clearly visible on previous slide
- Decrease in small bank ratio as activity is moved off-balance-sheet
- Increase in big bank ratio reflects more aggressive lending to non-financials. Annualized growth rates for Big Four:
  - 2005 to 2008 (actual): Loans 10.9%; Deposits 14.1%
  - 2008 to 2014 (actual): Loans 16.7%; Deposits 12.3%
  - 2008 to 2014 (purged of stimulus): Loans 12.9%; Deposits 9.8%
Interbank Conditions and Big Four Involvement

Source: PBOC and Wind Financial Terminal
Interbank Conditions and Big Four Involvement

- Big banks became net repo borrowers on 06/20, making policy banks the primary source of repo liquidity

- Big banks absorbed a lot of policy bank liquidity on 06/20 but no evidence that they really needed it:
  - Lent a sizable fraction of their borrowing volume
  - Lent at longer maturities than they borrowed

- Small banks were crowded out: large and positive spread between their weighted average borrowing cost and the policy loan rate

- Big banks charge more uniform loan rates and, on 06/20, commanded an abnormally high interest rate spread

- Collection of facts points to market manipulation by big banks
Calibration Results:

<table>
<thead>
<tr>
<th></th>
<th>(1) Model $\alpha = 0.14$</th>
<th>(2) Data 2007</th>
<th>(3) Model $\alpha = 0.25$</th>
<th>(4) Data 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Interbank Rate</td>
<td>3.35%</td>
<td>3.1%</td>
<td>3.6%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Small Bank WMPs</td>
<td>0.03</td>
<td>NA</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Big Bank WMPs</td>
<td>0.01</td>
<td>NA</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Big Bank Funding Share</td>
<td>0.52</td>
<td>0.55</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>Big Bank Loan-to-Deposit Ratio</td>
<td>58%</td>
<td>62%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>Credit-to-Savings Ratio</td>
<td>72.1%</td>
<td>65%</td>
<td>75.3%</td>
<td>75%</td>
</tr>
</tbody>
</table>

- We target the 2014 values of all variables in this table except for the credit-to-savings ratio. The 2007 values of these variables as well as the 2007 and 2014 values of the credit-to-savings ratio are generated by the model.

- Can also generate 90bps of the 150bps increase in the max interbank rate.
Quantitative Analysis

Estimation Results:

<table>
<thead>
<tr>
<th></th>
<th>Model with only $\sigma_\alpha$</th>
<th>Model with only $\sigma_{i_A}$</th>
<th>Model with only $\sigma_\Psi$</th>
<th>Model with $\sigma_\alpha, \sigma_{i_A}, \sigma_\Psi$</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{corr} (i_L, \xi_j)$</td>
<td>0.475</td>
<td>0.115</td>
<td>-0.008</td>
<td>0.458</td>
<td>0.456</td>
</tr>
<tr>
<td>$\text{corr} (i_L, \xi_k)$</td>
<td>0.318</td>
<td>0.411</td>
<td>-0.002</td>
<td>0.331</td>
<td>0.329</td>
</tr>
<tr>
<td>$\text{corr} (i_L, \xi_j - \xi_k)$</td>
<td>0.237</td>
<td>-0.227</td>
<td>-0.006</td>
<td>0.263</td>
<td>0.259</td>
</tr>
<tr>
<td>$\text{corr} (\xi_j, \xi_k)$</td>
<td>0.141</td>
<td>0.051</td>
<td>-0.004</td>
<td>0.730</td>
<td>0.736</td>
</tr>
<tr>
<td>$\text{corr} (\xi_j, \xi_j - \xi_k)$</td>
<td>0.811</td>
<td>0.662</td>
<td>0.932</td>
<td>0.565</td>
<td>0.550</td>
</tr>
<tr>
<td>$\text{corr} (\xi_k, \xi_j - \xi_k)$</td>
<td>-0.465</td>
<td>-0.714</td>
<td>-0.367</td>
<td>-0.151</td>
<td>-0.152</td>
</tr>
</tbody>
</table>

- Shocks to loan-to-deposit enforcement are more important than demand shocks or money supply shocks for explaining correlations between key interest rates.

- Also find that variation in $\alpha$ explains 46% of the variance in $i_L$ while variations in $i_A$ and the intercept of $\Psi (\cdot)$ explain only 21% and 34% respectively.
Conclusion

- Theory of unintended credit booms after stricter liquidity standards:
  - Regulatory arbitrage by small banks leads to shadow banking
  - Shadow banking creates competition with big banks
  - Allocation of savings across banks changes
  - Big banks respond by exploiting interbank market power
  - Allocation of lending across markets changes
  - In GE, the regulation has the opposite of its intended effect

- Application to China:
  - Strong empirical support for model’s cross-sectional predictions
  - Tightening of liquidity rules explains one-third of China’s credit boom from 2008 to 2014