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:

$$\begin{aligned} D_j &= \text{deposits} \\ W_j &= \text{deposit-like products (DLPs)} \\ \tau_j &= \text{fraction of DLPs sent off-b/s} \\ R_j &= \text{reserves} \end{aligned}$$

- Bank's liabilities:

$$\underbrace{D_j + (1-\tau_j)\, W_j}_{\text{on-b/s}} \quad + \quad \underbrace{\tau_j W_j}_{\text{off-b/s}}$$

- Bank's assets:

$$\underbrace{R_j}_{\text{reserves}} \quad + \quad \underbrace{D_j + (1-\tau_j)\, W_j - R_j}_{\text{on-b/s loans}} \quad + \quad \underbrace{\tau_j W_j}_{\text{off-b/s loans}}$$

Model Environment

- Loans are long-term:

$$\begin{array}{ccccc} \underline{t=0} & & \underline{t=1} & & \underline{t=2} \\ \$1 & \longrightarrow & \$0 & \longrightarrow & \$\left(1+i_A\right)^2 \end{array}$$

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

$$\begin{array}{ccccc} \underline{t=0} & & \underline{t=1} & & \underline{t=2} \\ \$1 & \longrightarrow & \$1 & \longrightarrow & \begin{cases} \$1 & \text{if } D_j \\ \$1+\xi_j & \text{if } W_j \end{cases} \end{array}$$

- Idiosyncratic withdrawals of deposits and DLPs:
  - With probability π, fraction θ_ℓ withdrawn at $t=1$ ("state ℓ")
  - With probability $1-\pi$, fraction is $\theta_h > \theta_\ell$ ("state h")

Model Environment

- Loan-to-deposit limit:

$$\underbrace{D_j + (1-\tau_j)\, W_j - R_j}_{\text{on-b/s loans}} \;\leq\; \underbrace{(1-\alpha)}_{\text{limit}} \cdot \underbrace{[D_j + (1-\tau_j)\, W_j]}_{\text{on-b/s deposits}}$$

  Rewrite as liquidity requirement: $\boxed{\lambda_j \equiv \frac{R_j}{D_j + (1-\tau_j) W_j} \geq \alpha}$

- 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, ξ_j, τ_j, and R_j to maximize expected profit subject to $\lambda_j \geq \alpha$
- Objective function:

$$\underbrace{(1 + i_A)^2 (D_j + W_j - R_j)}_{\text{from loans}} + \underbrace{(1 + i_L) \left[R_j - \overline{\theta} (D_j + W_j)\right]}_{\text{from surplus/shortage of reserves at } t=1}$$

$$- \underbrace{\left(1 - \overline{\theta}\right) \left[D_j + (1 + \xi_j) W_j\right]}_{\text{final payment to savers at } t=2} - \underbrace{\frac{\phi}{2} (D_j + W_j)^2}_{\text{operating cost (for later)}}$$

Baseline: Only Small Banks

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

$$W_j = \omega \xi_j$$

$$D_j + W_j = X + \rho \left(\xi_j - \overline{\xi} \right)$$

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

- In symmetric equilibrium, $\xi_j = \overline{\xi}$ and interbank market clears:

$$\underbrace{R_j + \psi i_L}_{\text{available liquidity}} = \underbrace{\overline{\theta} X}_{\text{required liquidity}}$$

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:

$$\xi_j = \underbrace{\frac{f(i_L) - \phi(D_j + W_j)}{2(1 - \overline{\theta})} \times \frac{\rho}{\omega}}_{\text{competitive motive for issuing DLPs}} + \underbrace{\frac{\alpha \mu_j \tau_j}{2(1 - \overline{\theta})}}_{\text{reg. arbitrage motive}}$$

- Consider $\rho = 0$ or ϕ high enough so no DLPs at $\alpha = 0$ (initial eqlm)
- Proposition:
  1. Increasing α 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 α (market mechanism at work)

Full Model: Adding a Big Bank

- Big bank (k) internalizes its effect on all endogenous variables
- Allocation of household savings:

$$D_k + W_k = \delta + \rho_1 \left(\xi_k - \overline{\xi_j}\right)$$

$$D_j + W_j = 1 - \delta + \rho_1 \left(\xi_j - \xi_k\right) + \rho_2 \left(\xi_j - \overline{\xi_j}\right)$$

- Small banks take as given ξ_k, $\overline{\xi_j}$, and interbank rate

Full Model: Adding a Big Bank

- In equilibrium, $\xi_j = \overline{\xi_j}$ and no reserve shortage at $t = 1$:
  - Market clearing when big bank's withdrawal shock is high:

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

  - To simplify, $i_L^\ell = 0$ when big bank's withdrawal shock is low

- At $t = 0$, the big bank chooses ξ_k, τ_k, and R_k to maximize its expected profit subject to:
  1. Liquidity rule $\lambda_k \geq \alpha$
  2. Small bank optimality conditions for ξ_j, τ_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

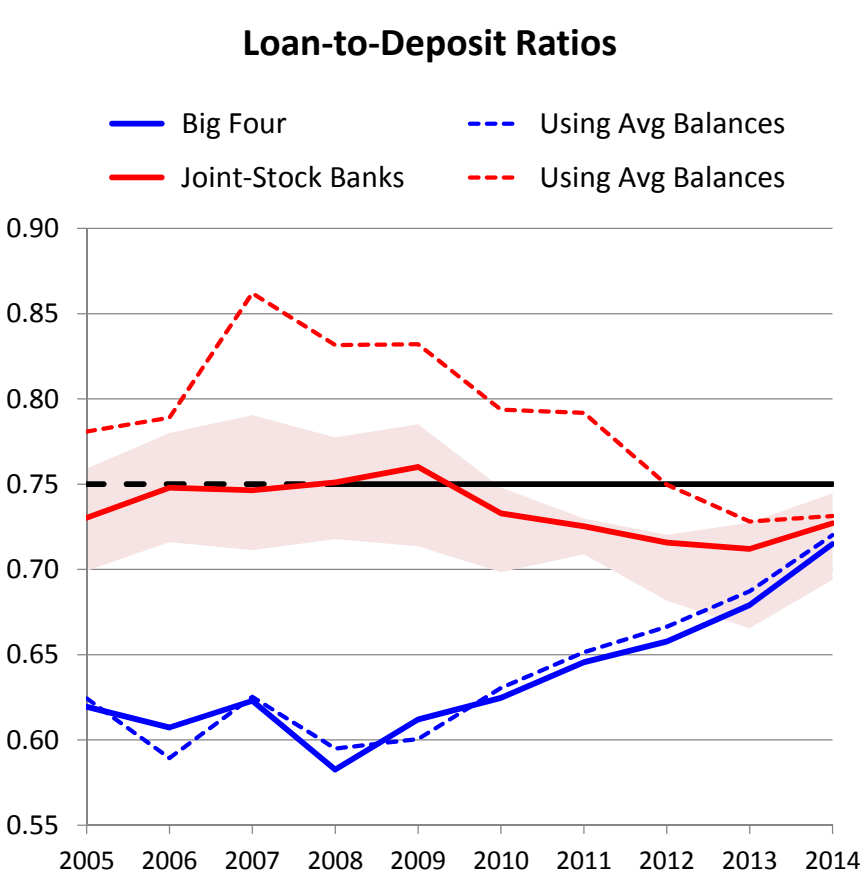
China: Cross-Sectional Facts

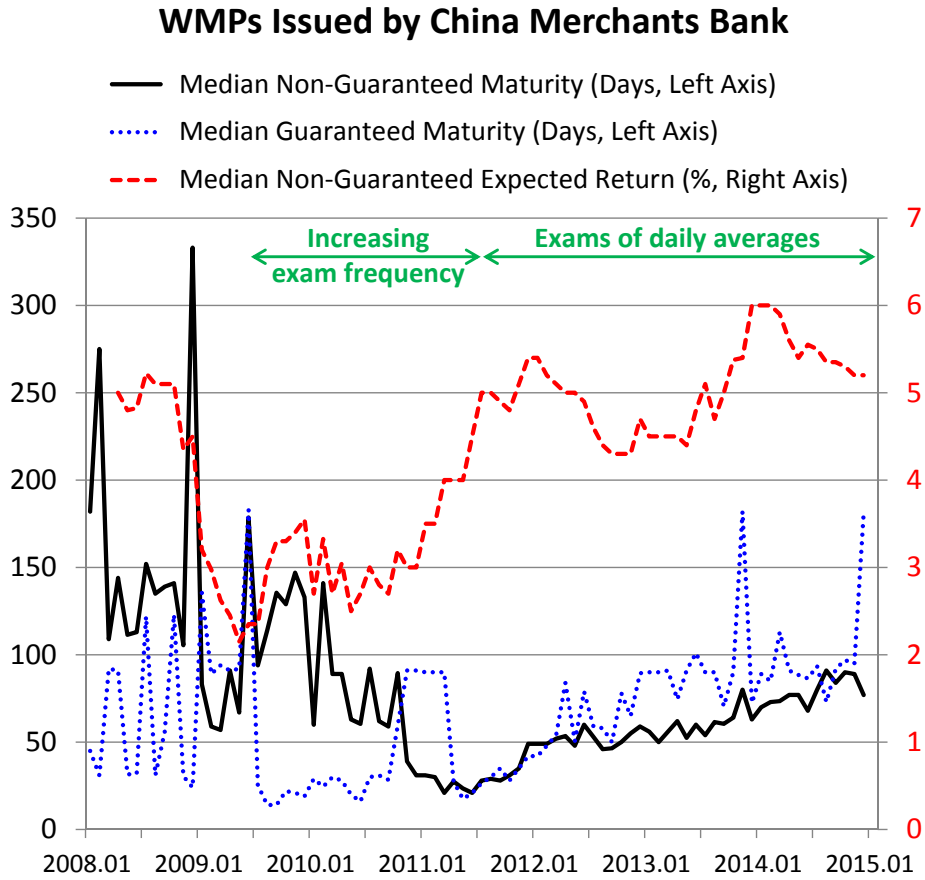
Shadow banking was driven by small banks

- 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





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

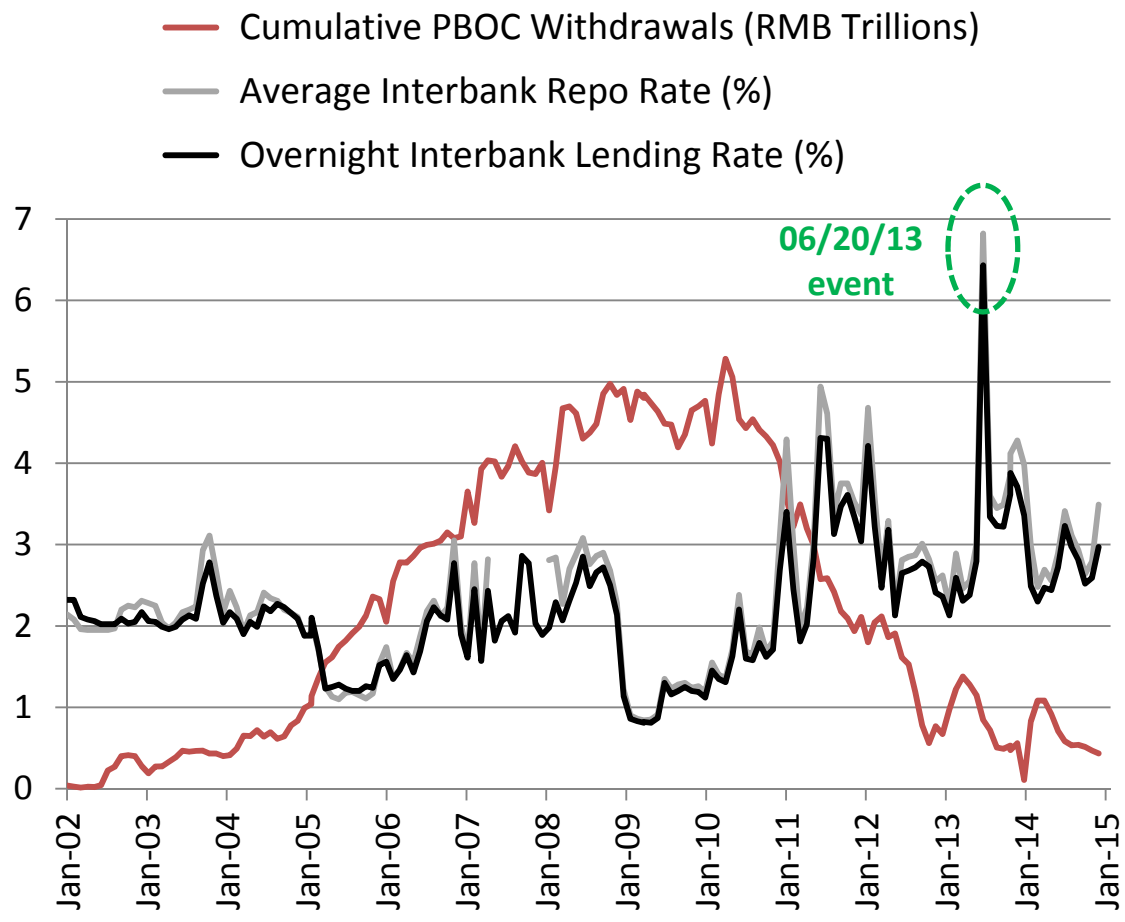
Sources: Bankscope, Bank Annual Reports, and Wind Financial Terminal

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

Quantitative Analysis

Calibration Results:

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

- 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:

	Model with only σ_α	Model with only σ_{i_A}	Model with only σ_Ψ	Model with σ_α, σ_{i_A}, σ_Ψ	Data
$corr\,(i_L, \xi_j)$	0.475	0.115	-0.008	0.458	0.456
$corr\,(i_L, \xi_k)$	0.318	0.411	-0.002	0.331	0.329
$corr\,(i_L, \xi_j - \xi_k)$	0.237	-0.227	-0.006	0.263	0.259
$corr\,(\xi_j, \xi_k)$	0.141	0.051	-0.004	0.730	0.736
$corr\,(\xi_j, \xi_j - \xi_k)$	0.811	0.662	0.932	0.565	0.550
$corr\,(\xi_k, \xi_j - \xi_k)$	-0.465	-0.714	-0.367	-0.151	-0.152

- 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 α 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