

# 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  $j$ :

$D_j$  = deposits

$W_j$  = deposit-like products (DLPs)

$\tau_j$  = fraction of DLPs sent off-b/s

$R_j$  = reserves

- ▶ Bank's liabilities:

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

- ▶ Bank's assets:

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

# Model Environment

- ▶ Loans are long-term:

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

- ▶ 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  - ▶ With probability  $\pi$ , fraction  $\theta_\ell$  withdrawn at  $t = 1$  ("state  $\ell$ ")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:

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

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

- ▶ 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:

$$\underbrace{(1 + i_A)^2 (D_j + W_j - R_j)}_{\text{from loans}} + \underbrace{(1 + i_L) [R_j - \bar{\theta} (D_j + W_j)]}_{\text{from surplus/shortage of reserves at } t=1}$$
$$- \underbrace{(1 - \bar{\theta}) [D_j + (1 + \xi_j) W_j]}_{\text{final payment to savers at } t=2} - \underbrace{\frac{\phi}{2} (D_j + W_j)^2}_{\text{operating cost (for later)}}$$

## Baseline: Only Small Banks

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

$$W_j = \omega \xi_j$$

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

- ▶ 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:

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

- ▶ Consider  $\rho = 0$  or  $\phi$  high enough so no DLPs at  $\alpha = 0$  (initial eqm)
- ▶ 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:

$$D_k + W_k = \delta + \rho_1 (\xi_k - \bar{\xi}_j)$$

$$D_j + W_j = 1 - \delta + \rho_1 (\xi_j - \xi_k) + \rho_2 (\xi_j - \bar{\xi}_j)$$

- ▶ Small banks take as given  $\xi_k$ ,  $\bar{\xi}_j$ , and interbank rate

# Full Model: Adding a Big Bank

- ▶ 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,  $i_L^\ell = 0$  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

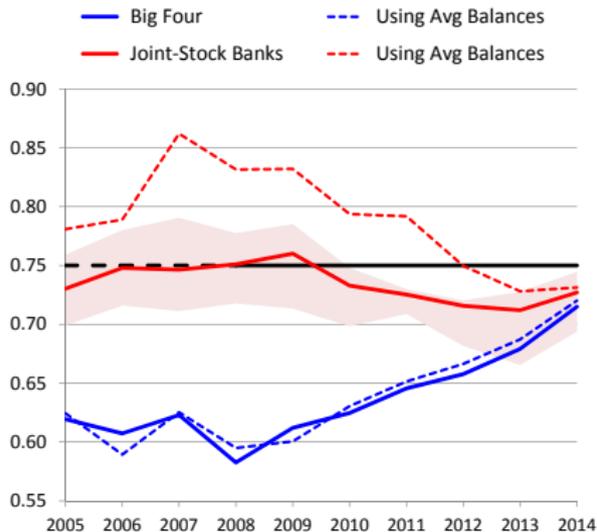
Shadow banking was driven by small banks

- ▶ 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

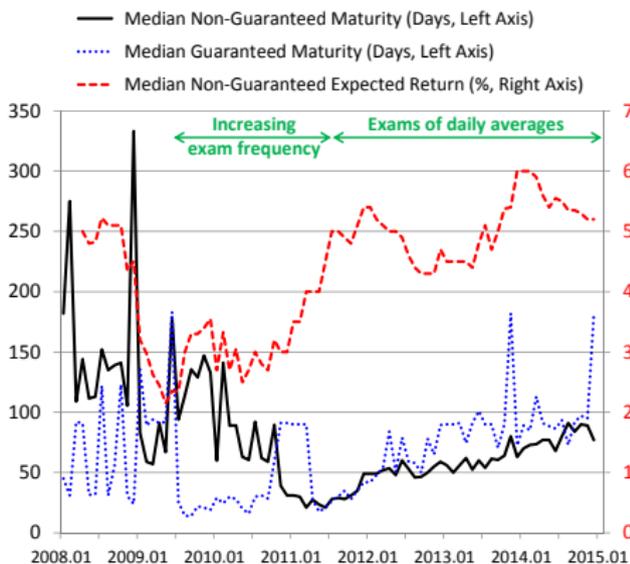
# China: Cross-Sectional Facts

Small banks were responding to liquidity rules

## Loan-to-Deposit Ratios



## WMPs Issued by China Merchants Bank



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

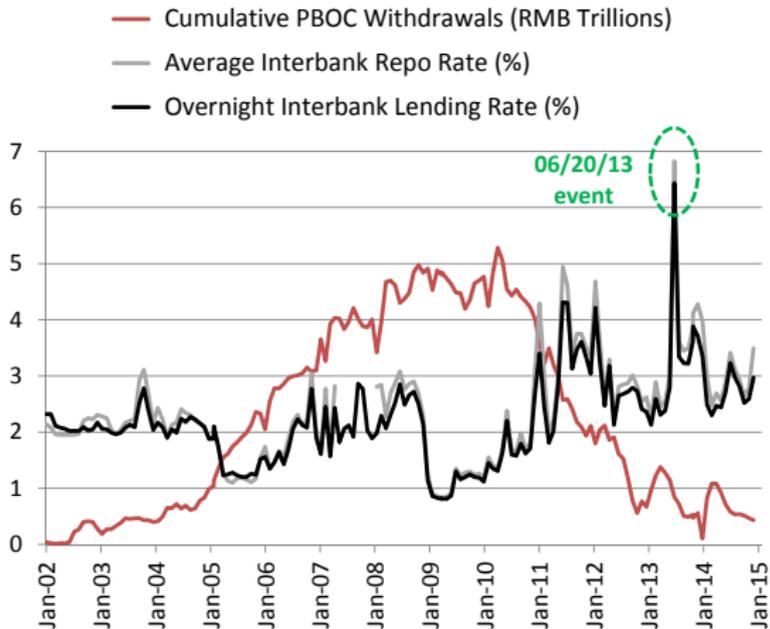
Sources: Bankscope, Bank Annual Reports, and Wind Financial Terminal

# 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 $\sigma_\alpha$	Model with only $\sigma_{i_A}$	Model with only $\sigma_\Psi$	Model with $\sigma_\alpha, \sigma_{i_A}, \sigma_\Psi$	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  $\alpha$  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