Wholesale Banking and Bank Runs in Macroeconomic Modelling of Financial Crises

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A key feature of the recent crisis is banking crisis

Slow run on shadow banks from Summer 2007, followed by fast run after Lehman failure in Fall 2008

Spreads between safe/liquid assets and risky/illiquid assets rose and investments fell → deep recession

Before the crisis, wholesale funding by financial intermediaries expanded significantly

What drives the expansion?

Efficiency gain?

Possibility of run in wholesale funding market?

Why should we care about run?
<table>
<thead>
<tr>
<th>Retail</th>
<th>Private Depository Institutions</th>
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<tbody>
<tr>
<td>Sector</td>
<td>Money Market Mutual Funds</td>
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<td></td>
<td>Mutual Funds</td>
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<tr>
<td>Wholesale</td>
<td><strong>Originate</strong>: Financing Companies</td>
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<td>Sector</td>
<td>Real Estate Investment Trusts</td>
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<td></td>
<td><strong>Securitize</strong>: Government Sponsored Enterprises</td>
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<td>Security Brokers Dealers</td>
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<td></td>
<td>ABS Issuers</td>
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<td><strong>Hold</strong>: GSE Mortgage Pools</td>
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<td>Funding Companies</td>
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<td>Holding Companies</td>
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</table>
Figure 1: Modes of Financial Intermediation

Households → Wholesale Banks
- Wholesale Funding (B)
  ↓
Retail Banks
- Wholesale Holdings (K^w)
  ↓
- Deposits (D)
  ↓
- Direct Holdings (K^h)
  ↓
Productive Asset
- Retail Holdings (K^r)
  ↓
- Direct Holdings (K^d)
  ↓

Figure 2: Wholesale Intermediation

Originators
- ABS
  ↓
Issuers
- Wholesale Funding Markets
  ↓
- Retail Banks
  ↓
Brokers & Conduits
- Securitization
  ↓
- ABS Issuers
  ↓
- Originators
  ↓
- Loans
  ↓
Ultimate Borrower
- Wholesale Funding Markets
  ↓
Retail Banks
The graph shows the evolution of credit intermediated by the three different sectors. Nominal data from the flow of funds are deflated using the CPI and normalized so that the log of the normalized value of real wholesale intermediation in 1980 is equal to 1. The resulting time series are then multiplied by 100.
Figure 4: Brokers Leverage

Leverage is given by the ratio of total assets over equity. Equity is computed from the flow of funds by subtracting liabilities other than "holding companies equity investment" from total assets. The net position leverage computes assets by netting out long and short positions in REPO and Security Credit.
The graph shows the logarithm of the real value outstanding. Nominal values from Flow of Funds are deflated using the CPI.
The graph shows the logarithm of the real value outstanding. Nominal values from Flow of Funds are deflated using the CPI and normalized so that the log of the normalized value of retail short term funding in 2001 is equal to 100.
Figure 7: Investment Collapse

Spreads and Investment

Percentage Points

Billions of (2009) Dollars

ABCP Spread  FIN CP Spread  Excess Bond Premium  Total Investment
Residential Investment  Durables  Business Investment
We develop a macro model of wholesale and retail banks and households

Wholesale banks are better at making business loans

Friction in interbank market is smaller than retail financial market

Financial innovation: reducing friction in interbank market → wholesale banks borrow more from retail banks

leverage of each bank $\uparrow \uparrow >$ net leverage of banking sector $\uparrow$

Improve efficiency: larger steady state output and smaller financial accelerator

But wholesale banks are more vulnerable to roll-over risk, or "bank run"
Basic Model

Capital is either intermediated by banks or held by households

\[ K_t^w + K_t^r + K_t^h = \overline{K} \]

\[
\begin{align*}
\text{date } t & \quad \text{date } t+1 \\
K_t^j & \text{ capital} \quad \rightarrow \quad K_t^j & \text{ capital} \\
F^j(K_t^j) & \text{ goods} & Z_{t+1}K_t^j & \text{ output}
\end{align*}
\]

\[ F^j(K_t^h) = \frac{\alpha^j}{2} (K_t^j)^2 : \text{management cost} \]

\[ \alpha^h > \alpha^r > \alpha^w = 0 \]

Retail bank pays \( f_t^r = F^{r'}(K_t^j) \) fee per unit of capital to households who provide management service
Retail deposit and interbank loan contracts

Short term

Promised rates of returns $\bar{R}_{t+1}$ and $\bar{R}_{bt+1}$ are non-contingent

With run, the return to the creditor is the minimum of the promised return and total realized debtor bank assets per outstanding credit

In Basic Model, bank run is unanticipated
Households maximize

\[ U_t = E_t \left( \sum_{i=0}^{\infty} \beta^i \ln C_{t+i}^h \right) \]

subject to:

\[ C_t^h + D_t + Q_t K_t^h + F^h(K_t^h) \]

\[ = Z_t W^h + R_t D_{t-1} + (Z_t + Q_t) K_{t-1}^h + f_t^r K_t^r - F^r(K_t^r) \]

\[
\rightarrow \\
1 = E_t \left( \beta \frac{C_t}{C_{t+1}} \cdot \frac{Z_{t+1} + Q_{t+1}}{Q_t + F^h(K_t^h)} \right)
\]
Many bankers of type $j = w, r$

Each has an i.i.d. survival probability of $\sigma^j$

Banker consumes wealth upon exit: $c_t^j = n_t^j$

Preferences are linear in "terminal" consumption

$$V_t^j = E_t \left[ \sum_{i=1}^{\infty} \beta^i (\sigma^j)^{i-1} (1 - \sigma^j) c_{t+i}^j \right]$$

Each exiting banker replaced by a new banker with an endowment $w^j = n_t^j$

Net worth $n_t^j$ of surviving bankers

$$n_t^j = (Z_t + Q_t) k_{t-1}^j - R_t d_{t-1}^j - R_{bt} b_{t-1}^j$$
$Z_t$ is realized

B/S of Bank $j$

<table>
<thead>
<tr>
<th>Bank loan:</th>
<th>Deposit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(Q_t + f_t)k_t$</td>
<td>$d_t$</td>
</tr>
<tr>
<td>Interbank loan:</td>
<td>$b_t$</td>
</tr>
<tr>
<td>Net worth:</td>
<td></td>
</tr>
<tr>
<td>$n_t$</td>
<td></td>
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</table>

$V_t$ is a divertible asset, $V_t \leq V_t$

- Continue: $V_t$
- Repay $R_{t+1}d_t$ and $R_{bt+1}b_t$
- Retain $n_{t+1}$
- Exit or continue

- $\theta(d_t + n_t + \omega b_t)$, for $b_t > 0$
- $\theta[(Q_t + f_t)k_t + \gamma(-b_t)]$, for $b_t < 0$

Incentive constraint:

\[
\theta(d_t + n_t + \omega b_t), \quad \text{for } b_t > 0 \\
\theta[(Q_t + f_t)k_t + \gamma(-b_t)], \quad \text{for } b_t < 0
\]
Bank $j$ chooses $(d_t^j, b_t^j)$ to maximize

$$V_t^j = \beta E_t \left[ \left( 1 - \sigma^j + \sigma^j \frac{V_{t+1}^j}{n_{t+1}^j} \right) n_{t+1}^j \right]$$

$$= E_t \left\{ \Omega_{t+1}^j \left[ R_{kt+1}^j n_t^j + \left( R_{kt+1}^j - R_{t+1} \right) d_t^j + \left( R_{kt+1}^j - R_{bt+1} \right) b_t^j \right] \right\}$$

where

$$\Omega_{t+1}^j = \beta \left( 1 - \sigma^j + \sigma^j \frac{V_{t+1}^j}{n_{t+1}^j} \right)$$

$$R_{kt+1}^j = \frac{Z_{t+1} + Q_{t+1}}{Q_t + f_t^j}$$

subject to the incentive constraint
Wholesale banks

\[ D^w_t = 0, \text{ if } \]
\[ \omega E_t \left[ \Omega^w_{t+1}(R^w_{kt+1} - R_{t+1}) \right] < E_t \left[ \Omega^w_{t+1}(R^w_{kt+1} - R_{bt+1}) \right]. \]

\[ Q_t K^w_t = \phi^w_t N^w_t = N^w_t + B_t \]

\[ \phi^w_t = \frac{E_t(\Omega^w_{t+1} R^w_{kt+1}) - \theta(1 - \omega)}{\theta \omega - E_t \left[ \Omega^w_{t+1}(R^w_{kt+1} - R_{bt+1}) \right]} \]

Retail banks

\[ (Q_t + f^r_t)K^r_t + \gamma B_t = \phi^r_t N^r_t \]

\[ \phi^r_t = \frac{E_t(\Omega^r_{t+1} R_{t+1})}{\theta - E_t \left[ \Omega^r_{t+1}(R^r_{kt+1} - R_{t+1}) \right]} \]

\[ N^j_t = \sigma^j \left[ (Z_t + Q_t) K^j_{t-1} - R_tD^j_{t-1} - R_{bt}B^j_{t-1} \right] + (1-\sigma^j)w^j \]
\[ Q_t K^w_t = N^w_t + B_t \]

\[ Q_t K^r_t \]

\[ Q_t K^h_t \]

Wholesale Banks

Retail Banks

Business: \( Q_t \bar{K} \)

Direct Finance

Households

Deposit \( D_t \)

Interbank Loan \( B_t \)
Financial Innovation: A Permanent Fall in $\omega$

Wholesale banks borrow more from retail banks with higher leverage

Retail banks reduce business loans

Leverage multiples of individual bank is higher, but

$$\frac{Q_t K_t^w + (Q_t + f_t^r) K_t^r}{N_t^w + N_t^r} < \frac{(Q_t + f_t^r) K_t^r + B_t}{N_t^r} < \frac{Q_t K_t^w}{N_t^w}$$

Economy becomes more efficient with larger net output

Financial accelerator becomes SMALLER
### PARAMETERS

<table>
<thead>
<tr>
<th>Households</th>
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<tbody>
<tr>
<td>β</td>
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### STEADY STATE

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<tr>
<td>Q</td>
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<td>R^b</td>
<td>Annual interbank rate</td>
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<td>Annual retail return on capital</td>
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<td>R</td>
<td>Annual deposit rate</td>
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<tr>
<td>N^w</td>
<td>wholesale banks networth</td>
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Figure 9: Low Frequency Dynamics in Financial Intermediation

\[ \omega = 0.61401 \]
\[ \omega = 0.46402 \]

Data
Figure 11: A recession before and after financial innovation (NO RUN EQUILIBRIUM)
Wholesale Bank Runs

Ex ante, zero probability of a run

If retail banks do not roll over their interbank credit ("run"), the wholesale banks sell their capital to households and retail banks who are less efficient in managing capital

In addition to an equilibrium without run, bank run equilibrium exists if:

\[ (Z_t + Q_t^*) K_{t-1}^w < R_{bt} B_{t-1} \]

\( Q_t^* \equiv \) the liquidation price of the bank’s assets
After a bank run at $t$:

$$K_t^h + K_t^r = \overline{K},$$

$$N_{t+1}^w = (1 - \sigma^w)w^w + \sigma^w(1 - \sigma^w)w^w$$

$$N_s^w = \sigma^w [(Z_s + Q_s) K_{s-1}^w - R_{bs} B_{s-1}] + (1 - \sigma^w)w^w, \forall \ s \geq t+2$$

Household condition for direct capital holding $\rightarrow$

$$Q_t^* = E_t \left\{ \sum_{i=1}^{\infty} \Lambda_{t,t+i} [Z_{t+i} - \alpha^h K^{h}_{t+i}] \right\} - \alpha^h K^h_t$$
Figure 12: A recession followed by a run on wholesale bankers only
Anticipated Bank Runs

Deposit returns $R_{bt+1} = \begin{cases} 
R_{bt+1} & \text{if no bank run} \\
x_{bt+1}R_{bt+1} & \text{if bank run}
\end{cases}
$

$$x_{bt+1} = \min \left[ 1, \frac{(Q_{t+1}^* + Z_{t+1}) K_w}{R_{bt+1}B_t} \right]$$

Household attaches the probability of bank run as

$$p_t = p(E_t(x_{bt+1})), \quad p(1) = 0, \quad p'(\cdot) < 0$$

FONC for interbank loan is

$$E_t[(1-p_t)\Omega_{t+1}^r(\overline{R}_{bt+1}-R_{t+1}) + p_t\Omega_{t+1}^{r*}(x_{bt+1}\overline{R}_{bt+1} - R_{t+1})] = \gamma E_t[(1-p_t)\Omega_{t+1}^r(R_{kt+1}^r-R_{t+1}) + p_t\Omega_{t+1}^{r*}(R_{kt+1}^{r*}-R_{t+1})]$$
Figure 13: A recession in the model with anticipated runs
Figure 14: A recession followed by a run in the model with anticipated runs.
Some Remarks About Policy

Capital requirement on all the large banks reduces likelihood of bank run

Can reduce the efficiency of intermediation

Lender-of-last resort stabilizes liquidation price

May reduce the likelihood of run

But increases the leverage multiple ex ante and the financial accelerator
Figure 20: Macro Prudential Policy: $\phi^w = 1.1\phi^{ss}$
Types of Steady State Equilibrium

- $K^r > 0$
- $B > 0$
- $D^w = 0$
- $B = 0$
- $B, D^w > 0$
- $D^w = 0$