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 rose and investments fell

Rapid rise in research that incorporates banking and banking crisis in macro models

A limitation: Mostly focus on retail banks, while the crisis centered around wholesale banks

Wholesale funding by financial intermediaries expanded significantly before the crisis

What are the driving forces? Efficiency gain?

Possibility of run in wholesale funding market?
<table>
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<th>Retail Sector</th>
<th>Private Depository Institutions</th>
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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.
The graph shows the logarithm of the real value outstanding. Nominal values from Flow of Funds are deflated using the CPI.
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We develop a macro model of wholesale and retail banks and households.

Wholesale banks are better at making business loans.

Banks are better in monitoring other banks than households.

Financial innovation: better monitoring of other banks → 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

\[ K^w_t + K^r_t + K^h_t = \bar{K} \]

\begin{align*}
\text{date } t & \quad \text{date } t+1 \\
K^j_t \text{ capital} \quad \rightarrow \quad K^j_t \text{ capital} \\
F^j(K^j_t) \text{ goods} \quad \rightarrow \quad Z_{t+1}K^j_t \text{ output} \\
F^j(K^h_t) &= \frac{\alpha^j}{2} (K^j_t)^2 : \text{management cost} \\
\alpha^h &> \alpha^r > \alpha^w = 0
\end{align*}

Retail bank pays \( f^r_t = F^{r'}(K^j_t) \) fee per unit of capital to households who provide management service.
\[ Q_t K^w_t = N^w_t + B_t \]

Retail Banks

Interbank Loan

Deposit

Direct Finance

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

Households

Wholesale Banks

\[ Q_t K^r_t \]

\[ Q_t K^h_t \]
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

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

subject to:

\[ C^h_t + D_t + Q_t K^h_t + F^h(K^h_t) \]

\[ = Z_t W^h + R_t D_{t-1} + (Z_t + Q_t) K^h_{t-1} + f^r K^r_t - F^r(K^r_t) \]

\[ \rightarrow \]

\[ 1 = E_t \left( \beta \frac{C_t}{C_{t+1}} \right) R_{t+1} \]

\[ 1 = E_t \left( \beta \frac{C_t}{C_{t+1}} \cdot \frac{Z_{t+1} + Q_{t+1}}{Q_t + F^{h'}(K^h_t)} \right) \]
Many bankers of type $j = w, r$

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

Banker consumes wealth upon exit: $c^j_t = n^j_t$

Preferences are linear in "terminal" consumption

$$V^j_t = E_t \left[ \sum_{i=1}^{\infty} \beta^i (\sigma^j)^{i-1} (1 - \sigma^j) c^j_{t+i} \right]$$

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

Net worth $n^j_t$ of surviving bankers

$$n^j_t = (Z_t + Q_t) k^j_{t-1} - R_t d^j_{t-1} - R_{bt} b^j_{t-1}$$
$Z_t$ is realized

B/S of Bank $j$

- Asset: $(Q_t + f_t)k_t$
- Deposit: $d_t$
- Interbank loan: $b_t$
- Net worth: $n_t$

Date $t$

Continue: $V_t$

- Incentive constraint:
  \[ \theta[d_t + n_t + \omega \max(b_t, 0)] \leq V_t \]

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

Date $t+1$

Bankrupt
Consider a bank with \( n^j_t = 1 \). The bank chooses \((Q_t + f^j_t)k^j_t\) and \(d^j_t\) to maximize

\[
V^j_t = \beta E_t \left\{ \left( 1 - \sigma^j + \sigma^j \frac{V^j_{t+1}}{n^j_{t+1}} \right) n^j_{t+1} \right\}
\]

\[
= \beta E_t \Omega^j_{t+1} \left[ (R^j_{kt+1} - R_{bt+1}) (Q_t + f^j_t)k^j_t + (R_{bt+1} - R_{t+1})d^j_t + R_{bt+1} \right]
\]

\[
= \mu^j_{kt}(Q_t + f^j_t)k^j_t + \mu^j_{bt}d^j_t + \nu^j_{bt}, \text{ where } R^j_{kt+1} = \frac{Q_{t+1} + Z_{t+1}}{Q_t + f^j_t}
\]

subject to

\[
V^j_t \geq \theta \left[ 1 + d^j_t + \omega \text{Max} \left( (Q_t + f^j_t)k^j_t - d^j_t - 1, 0 \right) \right]
\]
Wholesale banks

\[ D_t^w = 0, \text{ if } \omega \mu_{bt}^w < (1 - \omega) \mu_{kt}^w \]

\[ Q_t K_t^w = \phi_t^w N_t^w = N_t^w + B_t \]

\[ \phi_t^w = \frac{\nu_{bt}^w - \theta(1 - \omega)}{\theta \omega - \mu_{kt}^w} \]

Retail banks

\[ (Q_t + f_t^r) K_t^r + B_t = \phi_t^r N_t^r = N_t^r + D_t^r \]

\[ \phi_t^r = \frac{\nu_{bt}^r - \mu_{bt}^r}{\theta - \mu_{bt}^r} \]

\[ N_t^j = \sigma^j \left[ (Z_t + Q_t) K_{t-1}^j - R_t D_{t-1}^j - R_{bt} B_{t-1}^j \right] + (1 - \sigma^j) w^j \]
<table>
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<td>Annual interbank rate</td>
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<td>$R^w$</td>
<td>Annual deposit rate</td>
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<td>$R^k_w$</td>
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<tr>
<td>$N^w$</td>
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**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

$$\frac{Q_tK^w_t + (Q_t + f^r_t) K^r_t}{N^w_t + N^r_t} < \frac{(Q_t + f^r_t) K^r_t + B_t}{N^r_t} < \frac{Q_tK^w_t}{N^w_t}$$

Economy becomes more efficient with larger net output

Financial accelerator becomes SMALLER
Figure 10: Low Frequency Dynamics in Financial Intermediation

- $k_w$
- $k_r$
- B/D

Proportion of total intermediation
Ratio between WS and Retail short term funding
Figure 12: 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:

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

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

\[
K^h_t + K^r_t = \bar{K},
\]

\[
N^w_{t+1} = (1 - \sigma^w)w^w + \sigma^w(1 - \sigma^w)w^w
\]

\[
N^w_s = \sigma^w [(Z_s + Q_s) K^w_{s-1} - R_{bs} B_{s-1}] + (1 - \sigma^w)w^w, \; \forall \; s \geq t+2
\]

Household condition for direct capital holding →

\[
Q^*_t = E_t \left\{ \sum_{i=1}^{\infty} \Lambda_{t,t+i}[Z_{t+i} - \alpha^h K^h_{t+i}] \right\} - \alpha^h K^h_t
\]
Figure 14: A recession followed by a run on wholesale bankers only
Anticipated Bank Runs

Deposit returns \( R_{bt+1} = \begin{cases} \overline{R}_{bt+1} & \text{if no bank run} \\ x_{bt+1} \overline{R}_{bt+1} & \text{if bank run} \end{cases} \)

\[ x_{bt+1} = \text{Min} \left[ 1, \frac{(Q^*_t + Z_{t+1}) K^w_t}{\overline{R}_{bt+1} B_t} \right] \]

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

\[ E_t[(1-p_t)\Omega^r_{t+1}(R_{kt+1}^r - \overline{R}_{bt+1}) + p_t \Omega^r_{t+1}(R_{kt+1}^r - x_{bt+1} \overline{R}_{bt+1})] = 0 \]
Figure 15: A recession in the model with anticipated runs
Figure 16: A recession followed by a run in the model with anticipated runs