Banks, Credit Market Frictions, and Business Cycles

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Views expressed in this presentation are those of the author and do not necessarily reflect those of the Bank of Canada.
• The recent financial crisis demonstrates that a breakdown in the banking system can severely disrupt economic activity.

• Also, disturbances in the banking system can be a source of economic fluctuations.

• Financial conditions amplify and propagate the impact of real shocks to the economy.
Outline

• Motivation
• Modeling financial frictions
• Model
• Results
• Conclusion
• Future work
Motivation

• Models used by policymakers typically abstract from financial frictions (because of Modigliani-Miller theorem)

• In the literature, financial frictions introduced focusing only on the demand of credit:
  – Banks only play a passive role

• Few recent studies introduce banks in DSGE models: de Walque et al. (2008), Gerali et al. (2009), Gertler and Karadi (2009), and others.
This paper proposes a fully micro-founded framework to incorporate an active banking sector into a DSGE model. We introduce:

- demand- and supply-sides of credit markets
- an interbank market (to examine how interactions between banks affect credit supply)
- bank capital (to satisfy the bank capital requirements, Basel II, capital regulations)
- structural financial shocks (originating in the banking sector) and unconventional monetary shocks
Modeling Financial Frictions
Financial frictions are introduced based on:

   - This is to model the demand-side of credit markets

2. Bank’ balance sheet channel: shrinking balance sheet restrains banks’ ability to make loans and affects costs of producing loans (therefore, external financing costs)
   - This is to model the supply-side of credit markets
Corporate Balance Sheet Channel

• Entrepreneurs are subject to idiosyncratic shocks → may default on loans

• Information asymmetry and costly state verification imply an external finance premium, which depends on entrepreneurs’ net worth

• Unlike BGG, in this paper:
  – nominal debt contracts (to capture debt deflation effects)
  – external financing costs depend on the prime lending rate set by banks (instead of policy rate)
Bank Balance Sheet Channel

• The banking sector consists of a continuum of profit-maximizing monopolistically competitive banks

• To introduce an interbank market, we assume two types of banks that interact in the interbank market:
  – “savings banks” → lenders in the interbank market
  – “lending banks” → borrowers in the interbank market
Banks affect credit supply conditions through:

- **Monopoly power when setting deposit and loan rates → time-varying spreads in retail rates**
  - Deposit rate set as a mark-down of the interbank rate
  - Loan rate set as a mark-up of marginal costs of producing loans

- **Risk sharing with households and entrepreneurs**
  - Banks help consumption smoothing and efficient allocation of savings to risky investment

- **Endogenous (optimal) bank leverage ratio**
  - potential excess of bank capital holdings (capital buffer)
  - lower ratio implies lower costs of raising bank capital
• Endogenous bank defaults (strategic or mandatory), subject to penalties (Goodhart *et al.* 2006)

• Optimal banks' portfolio composition: split deposits between loans and holdings of risk-free assets
Questions

• What is the role of active banks in the U.S. business cycles: as an amplification and propagation mechanism?

• What are real effects of shocks originating in the banking sector?

• What is the importance of unconventional monetary policies in reducing effects of financial shocks?
Main findings

The model shows that:

• An active banking sector amplifies and propagates impacts of real shocks to the economy

• Bank leverage is procyclical

• Shocks originating in the banking sector can generate recessions

• Unconventional monetary policy has modest effects on the real economy
The Model
• A New Keynesian model for a closed economy built on BGG (1999)

• Real rigidity:
  - Habit formation on consumption
  - Bank capital adjustment costs
  - Investment adjustment costs

• Nominal rigidity:
  - Sticky prices à la Calvo-Yun contracts
  - Adjustment costs of changing deposit and prime lending rates
    (as in Gerali et al. 2009)
Structure of the BGG model

- **Central Bank**
  - Sets policy rate, \( R \)

- **Households**
  - Deposits
  - Transfer

- **Entrepreneurs**
  - Loans

- **Passive Banking Sector (Financial Intermediaries)**
  - Deposits = Loans
  - External financing cost depends on policy rate (\( R \)) and risk premium (\( rp \))

- Banks play a passive role

\[ f(R, rp) \]
Structure of the model

Households (Workers)

Central Bank

Sets policy rate, $R$

Injects liquidity

Swaps risky assets

Households (Bankers)

Active Banking Sector (continuum of optimizing banks)

Deposits ≠ Loans

Banks maximize profits

Government

Gov. Bonds

Deposits

Entrepreneurs

Bank capital

Loans
Structure of the model

- **Households (Workers):** Consume, work, hold cash, and make deposits.
- **Central Bank:** Own banks, consume, hold gov. bonds, and accumulate bank capital.
- **Government:** Deposit and receive liquidity injection.
- **Active Banking Sector (Deposits ≠ Loans):**
  - **Households (Bankers):** Own banks, consume, hold gov. bonds, and accumulate bank capital.
  - **Entrepreneurs:** Manage firms, borrow to finance part of investment, subject to idiosyncratic shocks, and may default.
  - **Bank capital:**
    - **Loans (risky assets):**
      - **Deposits:**

- **Economic Transactions:**
  - **Deposits**
  - **Gov. Bonds**
  - **Asset swapping**
  - **Liquidity injection**
Structure of the model

Households (Workers)

Entrepreneurs

Central Bank

Government

‘Active’ (optimizing) Banks

Deposits ≠ Loans

Households (Bankers)

Deposits

Gov. Bonds

Bank capital

Loans

Demand shocks

Policy shocks

Unconventional shocks

Financial intermediation shocks

Demand shocks

Supply shocks

Riskiness shocks

Riskiness: shock to std, of distribution, agency cost, or default threshold
Structure of the model

- **Central Bank**
  - Liquidity injection
  - Asset swapping

- **Households**
  - Deposits
  - Gov. Bonds
  - (Workers)

- **Government**
  - Savings
  - Lending
  - Interbank market

- **Interbank market**
  - Lenders in the interbank market
  - Borrowers in the interbank market

- **Entrepreneurs**
  - Loans

- **Savings Banks**
  - Interbank lending

- **Lending Banks**
  - Bank capital

- **Households**
  - (Bankers)
Structure of the model

- **Households (Workers)**
  - Deposits fully insured
  - Deposits $R^D$
  - Gov. bonds

- **Central Bank**
  - Liquidity injection
  - Asset swapping

- **Entrepreneurs**

- **Government**

- **Interbank market**
  - Interbank lending
  - Savings Banks
  - Lending Banks

- **Households (Bankers)**
  - Bank capital
  - Loans

- **Default on interbank borrowing**
Structure of the model

Households (Workers)
- Deposits $R^D$
- Government bonds $(1-s)D$

Central Bank
- Liquidity injection
- Asset swapping

Government

Savings Banks
- Set deposit rate $R^D$
- Split deposits between interbank lending, $sD$, and holdings of gov. bonds, $(1-s)D$

Interbank market
- Interbank lending $sD$
- $s$ decreasing in default on interbank borrowing

Entrepreneurs

Lending Banks
- Loans

Set deposit rate $R^D$, Split deposits between interbank lending, $sD$, and holdings of gov. bonds, $(1-s)D$
Structure of the model

Households (Workers)
- Deposits
- Gov. bonds

Central Bank
- $R^Z$ risky return on bank capital, increasing in default
- Default on bank capital

Government

Savings Banks
- Lending

Interbank lending

Lending Banks
- Loans
- Bank capital $R^Z$

Entrepreneurs

Transfer

Households (Bankers)
- Interbank market

Structure of the model

Lending banks use interbank borrowing and bank capital to produce loans.

Information asymmetry implies an external risk premium ($rp$).
Structure of the model

- **Households (Workers)**
  - Deposits
  - Gov. bonds

- **Government**
  - Central Bank
    - Deposits
    - Loans
    - Bank capital $R^Z$

- **Entrepreneurs**
  - Savings
  - Interbank lending
  - Lending Banks
    - $f(R^L, r_p)$

- **Households (Bankers)**
  - Bank capital $R^Z$
  - Loans

Set $R^L$, choose leverage ratio, and decide defaults on interbank lending and bank capital.
Structure of the model

External financing costs depend on loan prime rate \( R^L \) and \( rp \).

\[ f(R^L, rp) \]

\( R^L \) depends on marginal cost of producing loans \( (R, R^Z, \text{and banks' leverage ratio}) \).

Households (Workers)
- Deposits
- Gov. bonds

Households (Bankers)
- Bank capital \( R^Z \)

Government

Entrepreneurs

Central Bank

Deposits

Loans

Lending Banks

Liquidity injection

Asset swapping

Savings Banks

Interbank lending

Interbank market

External financing costs depend on loan prime rate \( R^L \) and \( rp \).
Banks
Savings banks

- Collect deposits from households (workers)
- Lend in the interbank market
- Set deposit rates as mark-down of the interbank rate
- Optimally choose the composition of their portfolio: interbank lending and holdings of risk-free assets
- Face default on their interbank lending
## Savings banks’ balance sheet

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gov. bonds: ((1-s)D)</td>
<td>Deposits: (D)</td>
</tr>
<tr>
<td>Interbank lending: (sD)</td>
<td></td>
</tr>
</tbody>
</table>
Lending banks

- Receive bank capital from households (bankers)
- Borrow on the interbank market
- Optimally choose their leverage ratio
- Set prime lending rate as mark-up of the marginal cost of producing loans
  - Marginal cost depends on the interbank rate and the marginal cost of raising bank capital, which is increasing in the bank leverage ratio
- Optimally decide to default on interbank borrowing and/or bank capital
Lending banks

- Produce loans using interbank borrowing and bank capital according to:

\[ L_t = \min \left\{ s_t D_t + m_t, \kappa_t \left( Q_t^Z Z_t + x_t \right) \right\} \Gamma_t \]

- Loans
- Interbank borrowing
- Bank capital value

Risky assets

\[ \begin{align*}
0 \leq s \leq 1 \\
D = \text{deposits}
\end{align*} \]

\[ Z = \text{claims on bank capital} \]

\[ Q_t^Z = \text{price of bank capital} \]
Lending banks

- Produce loans using interbank borrowing and bank capital according to:

\[
L_t = \min \left\{ s_t D_t + m_t, \kappa_t \left( Q_t^Z Z_t + x_t \right) \right\} \Gamma_t
\]

Leverage ratio subject to \( \kappa_t \leq \bar{\kappa} \) and gains of holdings of bank capital in excess:

\[
\frac{\chi}{2} \left( \frac{\bar{\kappa} - \kappa_t}{\kappa} Q_t^Z Z_t \right)^2
\]

Maximum imposed leverage ratio
Lending banks

- Produce loans using interbank borrowing and bank capital according to:

\[ L_t = \min \left\{ s_t D_t + m_t, \kappa_t \left( Q_t^Z Z_t + x_t \right) \right\} \Gamma_t \]

Financial intermediation shocks:
- Risk perception
- Fin. innovation
- Banking tech.
- Off-bal. sheet operations

Liquidity injections

Asset swapping
Lending banks

- Prime lending rate:

\[ R^L_t = \frac{\vartheta^L}{\vartheta^L - 1} \zeta_t - \text{Adj} j'_t + \beta E_t [\text{Adj} j'_{t+1}] \]

- Marginal cost of producing loans

\[ \zeta_t = \Gamma_t^{-1} \left[ R_t + \kappa_t^{-1} Q_t \left( R^Z_{t+1} - R_t - (R^L_t - 1) \left( \frac{\kappa - \kappa_t}{\bar{\kappa}} \right) \right) \right] \]
Lending banks

• Prime lending rate:

\[ R_t^L = \frac{\vartheta_L}{\vartheta_L - 1} \zeta_t - \text{Adj}_t' + \beta E_t [\text{Adj}_{t+1}'] \]

• Marginal cost of producing loans

\[ \zeta_t = \Gamma_t^{-1} \left[ R_t + \kappa_t^{-1} Q_t \left( R_{t+1}^Z - R_t - (R_t^L - 1) \left( \frac{\bar{\kappa} - \kappa_t}{\bar{\kappa}} \right) \right) \right] \]

Cost of interbank borrowing
Lending banks

• Prime lending rate:

\[
R^L_t = \frac{\vartheta_L}{\vartheta_L - 1} \zeta_t - Adj'_t + \beta E_t [ Adj'_{t+1} ]
\]

• Marginal cost of producing loans

\[
\zeta_t = \Gamma_t^{-1} \left[ R_t + \kappa_t^{-1} Q^Z_t \left( R^Z_{t+1} - R_t - (R^L_t - 1)(\frac{\bar{\kappa} - \kappa_t}{\bar{\kappa}}) \right) \right]
\]
Lending banks

• Prime lending rate:

\[ R_t^L = \frac{\mathcal{G}_L}{\mathcal{G}_L - 1} \zeta_t - \text{Adj}_t' + \beta E_t [\text{Adj}_t' + 1] \]

• Marginal cost of producing loans

\[ \zeta_t = \Gamma_t^{-1} \left[ R_t + \kappa_t^{-1} \mathcal{Q}_t \left( R_{t+1}^Z - R_t - (R_t^L - 1) \left( \frac{\bar{K} - \kappa_t}{\bar{K}} \right) \right) \right] \]

Cost of interbank borrowing

Cost of bank capital is increasing in leverage ratio

Marginal gain of holding bank capital in excess is decreasing in leverage ratio
### Lending banks’ balance sheet

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gov. bonds: $Q^ZZ + x$</td>
<td>Bank capital: $Q^ZZ$</td>
</tr>
<tr>
<td>Loans: $L - x$</td>
<td>Interbank borrowing: $sD$</td>
</tr>
<tr>
<td></td>
<td>Liquidity injection: $m$</td>
</tr>
<tr>
<td></td>
<td>Others: $(\Gamma - 1)(sD + m)$</td>
</tr>
</tbody>
</table>

- $x = \text{qualitative (credit) easing shock (swap a fraction of banks’ risky assets for risk-free assets)}$
- $m = \text{quantitative easing shock (liquidity injections that expend balance sheets)}$
Simulation Results
Simulation results

- Two versions of the model have been simulated:
  - **Baseline model**: the model with the banking sector and the financial accelerator
  - **FA model**: the model with only the financial accelerator (without the banking sector)
Simulation results

Table 1: Volatilities (Data 80:1-08:4)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Data</th>
<th>Baseline</th>
<th>FA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Standard deviations in %</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1.27</td>
<td>1.48</td>
<td>2.21</td>
</tr>
<tr>
<td>Investment</td>
<td>6.15</td>
<td>7.20</td>
<td>9.64</td>
</tr>
<tr>
<td>Consumption</td>
<td>1.06</td>
<td>1.26</td>
<td>1.61</td>
</tr>
<tr>
<td>Loans</td>
<td>4.21</td>
<td><strong>4.80</strong></td>
<td>4.24</td>
</tr>
<tr>
<td>Risk premium</td>
<td>0.38</td>
<td>0.44</td>
<td>0.51</td>
</tr>
<tr>
<td><strong>B. Relative volatilities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Investment</td>
<td>4.84</td>
<td>4.86</td>
<td>4.36</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.83</td>
<td>0.85</td>
<td>0.73</td>
</tr>
<tr>
<td>Loans</td>
<td>3.31</td>
<td><strong>3.25</strong></td>
<td>1.91</td>
</tr>
<tr>
<td>Risk premium</td>
<td>0.30</td>
<td>0.30</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Lower volatilities compared to FA, except for loans
Calibrated to reproduce relative volatilities
### Simulation results

**Table 2: Correlations with output (Data 80:1-08:4)**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Data</th>
<th>Baseline</th>
<th>FA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Investment</td>
<td>0.87</td>
<td>0.79</td>
<td>0.87</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.84</td>
<td>0.53</td>
<td>0.43</td>
</tr>
<tr>
<td>Loans</td>
<td>0.20</td>
<td>0.30</td>
<td>0.17</td>
</tr>
<tr>
<td>Risk premium</td>
<td>-0.30</td>
<td>-0.28</td>
<td>-0.55</td>
</tr>
<tr>
<td>Share of inter. lending</td>
<td>+</td>
<td>0.34</td>
<td>.</td>
</tr>
<tr>
<td>Bank leverage</td>
<td>+</td>
<td>0.51</td>
<td>.</td>
</tr>
<tr>
<td>Default on inter. lending</td>
<td>-</td>
<td>-0.35</td>
<td>.</td>
</tr>
<tr>
<td>Default on bank capital</td>
<td>-</td>
<td>-0.27</td>
<td>.</td>
</tr>
</tbody>
</table>

**Notes:**
- **Counter-cyclical**
- **Procyclical**
- **Risk premium**
- **Share of inter. lending**
- **Bank leverage**
- **Default on inter. lending**
- **Default on bank capital**

**Additional notes:**
- **Adjustments for interbank lending and bank leverage**
- **Countercyclical defaults**
Impulse Responses
Impulse Response Functions

- Propagation of standard shocks
  - Technology shock

- Structural financial shocks
  - Riskiness shock
  - Financial intermediation shock

- Unconventional monetary policy shocks
  - Liquidity injection (quantitative monetary easing)
Technology shocks
Figure 1: Responses to technology shocks

- Output
- Investment
- Consumption
- Inflation
- Policy rate
- Net worth
- Price of capital
- Risk premium
- Loans
- Leverage ratio
- Value of bank capital
- Share of Interb. lending
- Deposit rate
- Prime lending rate
- Default on Interb. borrowing
- Default on bank capital

FA model vs Baseline model
Figure 1: Responses to technology shocks

Banks amplify and propagate effects on output, investment and consumption.

Banks dampen effects on inflation and the policy rate.
Figure 1: Responses to technology shocks

Net worth decreases because of debt deflation and increase in lending rate on impact.

Risk premium increases and is higher with banks, because of larger drop of net worth.
Loans increase further in model with banks, because of the larger drop in net worth and increase in input used to produce loans: value of capital and interbank lending.

Leverage ratio increases, so bank extend Loans during booms.
Interest rate stickiness implies gradual responses, so moving and persistent spreads.

Prime lending increases on impact because of the increase in bank capital prices.
Both defaults fall, because of increase in bank capital and expansion in output.
Financial shocks
Figure 2: Responses to Riskiness shocks
10% increase in the riskiness shock (shock to the elasticity of risk premium). It may be shocks to std of entrepreneurial distribution, agency cost, or default threshold.

Banks are unable to discriminate between good and bad projects.

Higher risk premium for all borrowers.
Figure 2: Responses to Riskiness shocks

Higher risk premium lowers net worth. Thus, investment and output drops are lower in the model with banks.

Loans drop in short terms, then increase, because firms need loans to finance their investment.
Figure 2: Responses to Riskiness shocks

Leverage ratio increases because drop of bank capital is larger than that of loans. Banks expand loans.

Drop of interbank borrowing because banks make less loans.

Defaults increase.
Figure 3: Financial Intermediation Shocks

The figure illustrates the effects of financial intermediation shocks on various economic indicators. The graphs show the responses of output, investment, consumption, inflation, policy rate, net worth, price of capital, risk premium, loans, leverage ratio, value of bank capital, share of interbank lending, deposit rate, prime lending rate, and default on interbank borrowing and bank capital over time. The models compared are the FA model and the Baseline model.
Figure 3: Financial Intermediation Shocks

Output increases, inflation and policy rate fall (it is a supply shock)

Loans increase on impact, then decrease because increase in net worth and fall in marginal productivity of capital
Figure 3: Financial Intermediation Shocks

Investment gradually increases. Higher net worth.

Higher leverage ratio, since bank capital value falls.

Loan prime falls to accommodate the shock.

Bank capital and interb. borrowing fall. Banks need less inputs.
Figure 3: Financial Intermediation Shocks

Exogenous expansion of loans increases probabilities of defaults. Banks become fragile.
Unconventional monetary policy shocks
Figure 4: Monetary Injection Shocks
Figure 4: Monetary Injection Shocks

Net worth increases, while risk premium decreases.

Output and investment increase.
Figure 4: Monetary Injection Shocks

Bank capital and interbank borrowing decrease

Leverage ratio increases while loans fall one period later. This is due to the increase in net worth.

Loan prime decreases because the decrease in the marginal cost of producing loans
Figure 4: Monetary Injection Shocks

Defaults increase because of the fall of bank capital and in the marginal return of loans.
Conclusion

• We propose a micro-founded framework to model active banks and an interbank market: new sources of fluctuations and propagation mechanisms

• We examine the role of banks and financial shocks in the US business cycles

• Main findings are that:
  – The banking sector affects the propagation of real shocks
  – Financial shocks largely account for US business cycles
  – Bank leverage ratio is procyclical
  – Unconventional monetary policies have modest impacts
Future Work

• Estimation the model
• Incorporating credit to households
• Extending the approach to the international interbank market
• Addressing different monetary policy and financial stability issues: such as bank capital regulation (counter-cyclicality of bank leverage)