Banks, Credit Market Frictions and Business Cycles

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Introduction

- The current financial crisis underscores the need to develop DSGE models with real-financial linkages and a role for banking sector.
- The existing literature focuses mostly on the demand-side of the credit market, using BGG (1999) or Iacovello (2005) framework. Most DSGE models have ignored the importance of the banking sector and interbank markets.
- Few studies have examined the role of bank capital in determining credit supply conditions: Holmstrom and Turole (1997), Markovic (2006), and others.
This paper proposes a fully microfounded framework to incorporate an active banking sector and an interbank market into a DSGE model. Financial frictions are introduced using:

1. Corporate balance sheet channel—the financial accelerator à la BGG (1999);
2. Banking sector channels—Banks’ balance sheet.
Main features of the proposed framework are:

- Two types of heterogenous monopolistically competitive banks that interact in an interbank market.
- Loans are produced using interbank borrowing and bank capital—to satisfy the bank capital requirements (Basel II).
- Endogenous defaults on interbank borrowing and bank capital returns.
- Endogenous bank’s leverage ratio.
- Structural financial shocks—Financial intermediation, risk, quantitative and qualitative monetary easing shocks.
In this framework, the health and the behavior of banks can affect credit conditions and the real economy through the following channels:

1. Monopoly power in setting deposit and loan prime rates;
2. Endogenous defaulting of banks, but subject to penalties;
3. Banks’ portfolio compositions;
4. Endogenous banks’ leverage ratio;
5. Bank capital adjustment costs;
6. Bank capital price expectations;
7. Bank capital requirement conditions.
Related literature

- Goodhart, Sunirand and Tsomocos (2006)
- Christiano, Motto and Rostagno (2009)
- Gerali, Neri, Sessa and Signoretti (2009)
- Cúrdia and Woodford (2009)
Questions

- What is the role of the banking sector in the U.S. business cycles: as a propagation mechanism?
- What are real effects of structural financial shocks and their contributions to the U.S. business cycles?
Outline

- The model
- Calibration
- Results
- Conclusion
The Model
Model

- Two types of heterogenous households: workers and bankers.
- Two types of heterogenous banks: savings banks and lending banks.
- Production sector: entrepreneurs, capital producers, and retail firms.
- A central bank and the government.
Model

- Real rigidity:
  - Habit formation
  - Investment adjustment costs
  - Bank capital adjustment costs

- Nominal rigidity:
  - Sticky prices à la Calvo-type contracts in the retail sector
  - Adjustment costs of changing deposit and loan prime rates (thus, moving spreads)
Households

- They differ in preferences, risk aversion, and access to financial markets.

- **Workers** consume, supply labor to entrepreneurs, and save in money cash balances and deposits in savings banks.

- **Bankers** own banks, consume, buy government bonds, and accumulate bank capital (supplied to lending banks).
Banks: Savings banks

- A continuum of **savings banks** indexed by $j \in (0, 1)$
- receive deposits from workers (deposit fully insured);
- set deposit rates as a mark-down of the marginal return of their portfolio;
- choose the composition of their portfolio: interbank lending and government bonds;
- face a possible default on interbank lending and pay an insurance premium for holding risk-free assets.
Banks: Lending banks

- A continuum of **lending banks** indexed by $j \in (0, 1)$
- receive bank capital from bankers to satisfy the bank capital requirement condition;
- borrow from the interbank market;
- use interbank borrowing and bank capital to produce loans;
- set the loan prime rate as a markup of the marginal cost of producing loans;
- may optimally default on fractions of interbank borrowing and bank capital return, but subject to expected penalties;
- may swap a fraction of loans for bank capital injection.
Lending banks

Table 1: Lending banks’ balance sheet

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans ((L_t - x_t))</td>
<td>Interbank borrowing (\tilde{D}_t = s_tD_t)</td>
</tr>
<tr>
<td>Government bonds ((B_L^t = Q^Z_tZ_t + x_t))</td>
<td>Bank capital ((Q^Z_tZ_t))</td>
</tr>
<tr>
<td></td>
<td>Liquidity injection ((m_t))</td>
</tr>
</tbody>
</table>

Note: Swapping assets for bank capital injection, \(x_t\), affects only the composition of banks’ assets. However, quantitative monetary easing expands the balance sheets of the central bank and lending banks.
Lending banks

- Leontief technology to produce loans:

\[ L_{j,t} = \min \left\{ \tilde{D}_{j,t} + m_{j,t} ; \kappa_{j,t} \left( Q_t^Z Z_{j,t} + x_{j,t} \right) \right\} \Gamma_t \]

- **The bank’s leverage ratio**, \( \kappa_{j,t} < \bar{\kappa}_t \), is endogenous and optimally chosen by bank \( j \).

- \( \Gamma_t, x_t \) and \( m_t \sim AR(1) \) are financial intermediation, liquidity injection, and bank capital injection shocks.
Entrepreneurs

- Unlike BGG (1999), the external finance cost depends on loan prime rate, \( R^L_t \) set by lending banks.

- Debt contract:  
  \[
  E_t F_{t+1} = E_t \left[ \frac{R^L_t}{\pi_{t+1}} \left( \frac{Q^k_t K_{t+1}}{N_t} \right)^{\psi_t} \right].
  \]

- \( \psi_t \sim AR(1) \) is a risk shock similar to that in Christiano et al. (2009); \( \psi_t \) positively depends on the standard deviation of the entrepreneurs’ distribution, default threshold, and the agency cost parameter.
Central bank and government

- Monetary policy
  - Interest rule (standard Taylor rule):
    \[
    \frac{R_t}{R} = \left( \frac{\pi_t}{\pi} \right)^{\phi_{\pi}} \left( \frac{Y_t}{Y} \right)^{\phi_{Y}} \exp(\varepsilon R_t)
    \]
  - Quantitative monetary easing: liquidity injection into banking system, \( m_t \)
  - Qualitative monetary easing: swapping a fraction of loans for bank capital injections \( x_t \)
Calibration
The model’s structural parameters are calibrated for the U.S. economy using:

- Commonly used values;
- Estimated values in previous studies: BGG (1999), Christenson and Dib (2008), and Christiano et al. (2009);
- Values to match the data;
- OLS estimations.
### Table 3a: Parameter Calibration: Baseline model

<table>
<thead>
<tr>
<th>Financial sector</th>
<th>Preferences</th>
<th>Monetary policy</th>
<th>Technologies</th>
<th>Adjustment and default costs</th>
<th>Nominal rigidities</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \nu = 0.9833 ), ( \psi = 0.05 ), ( K/N = 2 ), ( \bar{\kappa} = 12.5 )</td>
<td>( \beta_w = 0.9979 ), ( \beta_b = 0.9943 ), ( \gamma_w = 3 ), ( \gamma_b = 1.5 ), ( \varphi = 0.65 ), ( \omega = 0.0003 ), ( \upsilon = 4 ), ( \eta = 0.996 ), ( \varsigma = 1 )</td>
<td>( \varrho_\pi = 1.2 ), ( \varrho_Y = 0.05 ), ( \sigma_R = 0.006 )</td>
<td>( \alpha = 0.33 ), ( \delta = 0.025 ), ( \theta = 6 ), ( \vartheta_{Rd} = 2.9 ), ( \vartheta_{Rl} = 2.7 )</td>
<td>( \chi_k = 10 ), ( \chi_z = 85 ), ( \chi_{\alpha d} = 0.0075 ), ( \chi_{\alpha z} = 30.13 ), ( \chi_{\delta d} = 227 )</td>
<td>( \chi_{\delta z} = 4472 ), ( \epsilon_{\alpha d} = 1.2 ), ( \epsilon_{\delta d} = 1.2 ), ( \epsilon_{\delta z} = 1.2 )</td>
</tr>
</tbody>
</table>
### Table 3b: Parameter Calibration: Baseline model

<table>
<thead>
<tr>
<th></th>
<th>Financial shocks</th>
<th>Supply shocks</th>
<th>Demand shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi$ = 0.05,</td>
<td>$\rho_\psi = 0.83$, $\sigma_\psi = 0.090$,</td>
<td>$A = 1$,</td>
<td>$e = 1$,</td>
</tr>
<tr>
<td>$\Gamma = 1$,</td>
<td>$\rho_\Gamma = 0.8$, $\sigma_\Gamma = 0.003$,</td>
<td>$\Upsilon = 1$,</td>
<td>$G/Y = 0.17$,</td>
</tr>
<tr>
<td>$m = 0$,</td>
<td>$\rho_m = 0.5$,</td>
<td>$\rho_\Upsilon = 0.7$, $\sigma_\Upsilon = 0.033$,</td>
<td>$\rho_G = 0.81$, $\sigma_G = 0.0166$,</td>
</tr>
<tr>
<td>$x = 0$,</td>
<td>$\rho_x = 0.5$,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\sigma_x = 0.005$,</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Empirical Results
Empirical results

Two versions of the model have been simulated:

1. **The baseline model**: the model with the banking sector and the financial accelerator;

2. **The FA model**: the model with the financial accelerator and without the banking sector.
Main results

Two versions of the model have been simulated:

- The banking sector affects the transmission and propagation of shocks: dampening the effect of technology, demand-side, and risk shocks.
- The banking sector reduces the volatility of macro variables.
- Financial shocks account for a large fraction of U.S. business cycles.
- Banks leverage ratio is procyclical.
- Banking sector is welfare improving.
### Table 4: Standard deviations and relative volatilities
(Data 1980:1–2008:4)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definitions</th>
<th>Data</th>
<th>Baseline</th>
<th>FA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(in %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A. Standard deviations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Y_t$</td>
<td>output</td>
<td>1.27</td>
<td><strong>1.57</strong></td>
<td>2.35</td>
</tr>
<tr>
<td>$I_t$</td>
<td>investment</td>
<td>6.15</td>
<td><strong>7.60</strong></td>
<td>11.36</td>
</tr>
<tr>
<td>$C_t$</td>
<td>consumption</td>
<td>1.06</td>
<td><strong>1.31</strong></td>
<td>1.79</td>
</tr>
<tr>
<td>$L_t$</td>
<td>loans</td>
<td>4.21</td>
<td><strong>5.32</strong></td>
<td>4.23</td>
</tr>
<tr>
<td>$r p_t$</td>
<td>risk premium</td>
<td>0.43</td>
<td><strong>0.73</strong></td>
<td>0.86</td>
</tr>
<tr>
<td><strong>B. Relative volatilities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Y_t$</td>
<td>output</td>
<td>1</td>
<td><strong>1</strong></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>$I_t$</td>
<td>investment</td>
<td><strong>4.84</strong></td>
<td><strong>4.84</strong></td>
<td><strong>4.83</strong></td>
</tr>
<tr>
<td>$C_t$</td>
<td>consumption</td>
<td>0.83</td>
<td>0.83</td>
<td>0.76</td>
</tr>
<tr>
<td>$L_t$</td>
<td>loans</td>
<td><strong>3.31</strong></td>
<td><strong>3.39</strong></td>
<td>1.80</td>
</tr>
<tr>
<td>$r p_t$</td>
<td>risk premium</td>
<td>0.34</td>
<td>0.46</td>
<td>0.36</td>
</tr>
</tbody>
</table>
Table 5: Correlations with output (Data 1980:1–2008:4)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definitions</th>
<th>Data</th>
<th>Baseline</th>
<th>FA</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>output</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>$I_t$</td>
<td>investment</td>
<td>0.87</td>
<td>0.79</td>
<td>0.85</td>
</tr>
<tr>
<td>$C_t$</td>
<td>consumption</td>
<td>0.84</td>
<td>0.54</td>
<td>0.58</td>
</tr>
<tr>
<td>$L_t$</td>
<td>loans</td>
<td>0.20</td>
<td>0.21</td>
<td>0.12</td>
</tr>
<tr>
<td>$rp_t$</td>
<td>risk premium</td>
<td>-0.30</td>
<td>-0.35</td>
<td>-0.53</td>
</tr>
<tr>
<td>$\alpha^s_t$</td>
<td>bank leverage ratio</td>
<td>+</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>$\alpha^d_t$</td>
<td>fraction of interbank lending</td>
<td>+</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>$\delta^d_t$</td>
<td>default on interbank borrowing</td>
<td>-</td>
<td>-0.24</td>
<td></td>
</tr>
<tr>
<td>$\delta^z_t$</td>
<td>default on bank capital</td>
<td>-</td>
<td>-0.05</td>
<td></td>
</tr>
</tbody>
</table>

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Table 6: Variance decompositions

<table>
<thead>
<tr>
<th></th>
<th>Supply shocks</th>
<th>Demand shocks</th>
<th>Financial shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\psi_t$</td>
</tr>
<tr>
<td>$Y_t$</td>
<td>31.22</td>
<td>16.58</td>
<td>31.02</td>
</tr>
<tr>
<td>$I_t$</td>
<td>29.45</td>
<td>4.39</td>
<td>40.39</td>
</tr>
<tr>
<td>$C_t$</td>
<td>41.53</td>
<td>23.79</td>
<td>20.93</td>
</tr>
<tr>
<td>$L_t$</td>
<td>64.24</td>
<td>6.31</td>
<td>13.11</td>
</tr>
<tr>
<td>$r p_t$</td>
<td>7.63</td>
<td>1.33</td>
<td>87.90</td>
</tr>
</tbody>
</table>

A. Baseline model

|                  |               |               |               |
| $Y_t$            | 9.67          | 23.37         | 66.96          |
| $I_t$            | 11.25         | 17.01         | 71.73          |
| $C_t$            | 19.53         | 24.77         | 55.70          |
| $L_t$            | 37.73         | 23.85         | 38.95          |
| $r p_t$          | 3.21          | 4.71          | 92.10          |

B. FA model
Impulse responses
Figure 1: Responses to a 1% Positive Technology Shock

- Output, $Y_t$
- Investment, $I_t$
- Inflation, $\pi_t$
- Policy rate, $R_t$
- Net worth, $N_t$
- Cap. price, $Q^K_t$
- Risk premium, $rp_t$
- Loans, $L_t$
- Bank leverage, $\kappa_t$
- Dep. frac., $S_t$
- Dep. default, $\delta^D_t$
- B.C. default, $\delta^Z_t$
- Dep. rate, $R^D_t$
- Prime rate, $R^L_t$

Different lines indicate FA model and Baseline model.
Figure 2: Responses to a 1% Intermediation Process Shock, $\Gamma_t$

<table>
<thead>
<tr>
<th>Graph</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output, $Y_t$</td>
<td></td>
</tr>
<tr>
<td>Investment, $I_t$</td>
<td></td>
</tr>
<tr>
<td>Inflation, $\pi_t$</td>
<td></td>
</tr>
<tr>
<td>Policy rate, $R_t$</td>
<td></td>
</tr>
<tr>
<td>Net worth, $N_t$</td>
<td></td>
</tr>
<tr>
<td>Cap. price, $Q^K_t$</td>
<td></td>
</tr>
<tr>
<td>Risk premium, $r_p_t$</td>
<td></td>
</tr>
<tr>
<td>Loans, $L_t$</td>
<td></td>
</tr>
<tr>
<td>Bank leverage, $\kappa_t$</td>
<td></td>
</tr>
<tr>
<td>Dep. frac., $S_t$</td>
<td></td>
</tr>
<tr>
<td>Dep. default, $\delta_t^D$</td>
<td></td>
</tr>
<tr>
<td>B.C. default, $\delta_t^Z$</td>
<td></td>
</tr>
<tr>
<td>Dep. rate, $R_t^D$</td>
<td></td>
</tr>
<tr>
<td>Prime rate, $R_t^L$</td>
<td></td>
</tr>
</tbody>
</table>

FA model: FA model
Baseline model: Baseline model
Figure 3: Responses to a 1% Increase in the Risk Shock, $\psi_t$

Output, $Y_t$

Investment, $I_t$

Inflation, $\pi_t$

Policy rate, $R_t$

Net worth, $N_t$

Cap. price, $Q^K_t$

Risk premium, $rp_t$

Loans, $L_t$

Bank leverage, $\kappa_t$

Dep. frac., $S_t$

Dep. default, $\delta^D_t$

B.C. default, $\delta^Z_t$

Dep. rate, $R^D_t$

Prime rate, $R^L_t$

- FA model
- Baseline model
Figure 4: Responses to a 1% Quantitative Easing Shock $m_t$

- Output, $Y_t$
- Investment, $I_t$
- Inflation, $\pi_t$
- Policy rate, $R_t$
- Net worth, $N_t$
- Cap. price, $Q^K_t$
- Risk premium, $rp_t$
- Loans, $L_t$
- Bank leverage, $\kappa_t$
- Dep. frac., $S_t$
- Dep. default, $\delta^D_t$
- B.C. default, $\delta^Z_t$
- Dep. rate, $R^D_t$
- Prime rate, $R^L_t$

FA model
Baseline model

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Figure 5: Responses to a 1% Qualitative Easing Shock, $x_t$

- Output, $Y_t$
- Investment, $I_t$
- Inflation, $\pi_t$
- Policy rate, $R_t$
- Net worth, $N_t$
- Cap. price, $Q^K_t$
- Risk premium, $r\pi_t$
- Loans, $L_t$
- Bank leverage, $\kappa_t$
- Dep. frac., $S_t$
- Dep. default, $\delta^D_t$
- B.C. default, $\delta^Z_t$
- Dep. rate, $R^D_t$
- Prime rate, $R^L_t$

Different models: FA model, Baseline model
Welfare Analysis

Table 7: Welfare analysis

<table>
<thead>
<tr>
<th></th>
<th>All of the shocks</th>
<th>Supply shocks</th>
<th>Demand shocks</th>
<th>Financial shocks: Risk, $\psi_t$</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Baseline model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare cost in %</td>
<td><strong>0.1406</strong></td>
<td><strong>0.0097</strong></td>
<td><strong>0.0511</strong></td>
<td><strong>0.0622</strong></td>
<td><strong>0.1030</strong></td>
</tr>
<tr>
<td><strong>B. FA model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare cost in %</td>
<td><strong>0.6953</strong></td>
<td><strong>0.0785</strong></td>
<td><strong>0.1346</strong></td>
<td><strong>0.4710</strong></td>
<td></td>
</tr>
</tbody>
</table>

A weighted average of workers and bankers' steady state of consumption.

- The banking sector reduces welfare costs by about 80%.
- Financial shocks account for 73% and 67% of welfare loss in the baseline and FA models, respectively.
Conclusion

- The paper proposes a micro-founded framework to incorporate credit and interbank markets into a New Keynesian model.
- The model examines the role of banking sector and financial shocks in the U.S. business cycles.
- The main findings are that:
  1. The banking sector affects the propagation of the shocks;
  2. Financial shocks largely account for U.S. business cycles;
  3. Bank leverage ratio is procyclical;
  4. Banking sector is welfare improving.
Future work

- Estimation of the model;
- Extending the approach to international interbank markets;
- Incorporating credit to households;
- Addressing different monetary policy and financial stability issues.