The Role of Bank Capital in the Propagation of Shocks

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2nd Bank of Italy Conference on Macro Modeling in the Policy Environment, Rome
July 1, 2009

The views expressed are those of the authors and not of the Bank of Canada.
Huge progress in building and estimating/calibrating DSGE models with financial frictions that tend to fit quarterly aggregate data well.

In practice, however, these models abstract from the state of the balance sheets of banks and interaction with real economy.

- Feature: Supply of funds of banks unaffected by their balance sheet.

The current crisis has reminded us that the state of the balance sheet of banks plays an important role in economic fluctuations.
GOAL OF THIS PAPER

1. We build a quantitative macroeconomic model in which bank capital is endogenous and matters.

2. We use the model to study how the presence of bank capital affects the transmission of shocks.
Accounting explicitly for the balance sheet position of banks in a general equilibrium model is important for aggregate fluctuations.

Economies in which banks experience a fall in bank capital during periods of negative technological shocks face sharper and persistent declines in bank lending and economic activity.

A sudden scarcity of banking capital (equity) depresses economic activity and affects the conduct of monetary policy.
LITERATURE

  - No bank capital

  - Market-determined and/or not quantitative

  - Bank Capital needed for exogenous reasons
OUTLINE

- Sketch of the model
  - New Keynesian DSGE models based on CEE and SW
  - Financial Intermediation and bank capital (HT)

- Findings

- Conclusion and Future Work
MODEL

**Final Good Sector**

- Competitive firms that assemble differentiate intermediate goods

\[ Y_t = \left( \int_0^1 Y_{jt}^{\xi_p} \, dj \right)^{\frac{\xi_p}{\xi_p - 1}}, \quad \xi_p > 1 \]

**Intermediate Good Sector**

- Monopolistic competitive firms produce differentiated intermediate goods

\[ Y_{jt} = z_t^{\theta_k} k_j^{\theta_k} h_j^{\theta_h} h_e^{\theta_e} h_{jt}^{\theta_b} b_{jt}^{\theta_b}, \quad z_t \sim AR(1) \]

- Face sticky price à la Calvo
- Partial indexation to previous inflation rate if no price changes
**Investment Good Sector**

- **Entrepreneurs** need external funds from banks to make investments
- Experience idiosyncratic productivity shock: $\tilde{R}_i$
- Can divert the resource and obtain a private return proportional to the size of the investment: $\tilde{b}_i$
- Diversion affects the probability of success of the project

**Banking Sector**

- **Bankers** are endowed with a monitoring technology
- Cost of monitoring for investment size $i_t$: $\mu_i$
- Monitoring activity is not public observable $\Rightarrow$ so bankers may not monitor adequately
LENDING RELATIONSHIP

Two Sources of Moral Hazard

1. Moral Hazard
   Entrepreneurs may privately choose low return projects to enjoy private benefits

2. Moral Hazard
   Banks have an incentive not to monitor in order to save costs

Entrepreneurial Net Worth

Bank Net Worth
Investment Projects

- Three types of projects available to the entrepreneur:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Private benefits</td>
<td>0</td>
<td>$b_i^t$</td>
<td>$B_i^t$</td>
</tr>
<tr>
<td>Prob. of success</td>
<td>$\alpha^g$</td>
<td>$\alpha^b$</td>
<td>$\alpha^b$</td>
</tr>
</tbody>
</table>

- Good project is socially desirable

- Bank monitoring can eliminate only project with highest private returns

- The projects financed by an individual bank are perfectly correlated
HOUSEHOLD AND CENTRAL BANK


Household Sector

- Utility function: \( u(\cdot) = \log(c^h_t - \gamma c^h_{t-1}) + \psi \log(1 - l^h_{it}) + \zeta \log(M^c_t / P_t) \)
- Habit formation in consumption
- Monopolistic supplier of specialized labor input
- Sticky wage à la Calvo with parameter
- Variable capital utilization
- Ultimate suppliers of funds to entrepreneurs via banks

Central Bank

- Set monetary policy according to a Taylor Rule

\[
 r^d_t = (1 - \rho_r) r^d + \rho_r r^d_{t-1} + (1 - \rho_r) [\rho_{\pi} (\pi_t - \bar{\pi}) + \rho_{\hat{y}} \hat{y}_t] + \epsilon^{mp}_t
\]
Financial Contract

- One optimal contract will have the following structure:
  - the entrepreneur invests all his net worth
  - if success, $R$ is distributed among the entrepreneur, the banker and the households: $R = R^e_t + R^b_t + R^h_t$
  - if failure, neither party is paid anything

Objective of the contract:
Choose project size and payment shares to maximize expected payoff to entrepreneurs subject to five constraints
Financial Contract, continued

- Incentive constraint of bankers: \( q_t \alpha^g R_t^b i_t - \mu i_t \geq q_t \alpha^b R_t^b i_t \)

- Incentive constraint of entrepreneurs: \( q_t \alpha^g R_t^e i_t \geq q_t \alpha^b R_t^e i_t + q_t b i_t \)

- Participation constraint of bankers: \( q_t \alpha^g R_t^b i_t \geq (1 + r_t^a) a_t \)

- Participation constraint of households: \( q_t \alpha^g R_t^h i_t \geq (1 + r_t^d) d_t \)

- Resource constraint: \( a_t + d_t - \mu i_t \geq i_t - n_t \)
Upshot of the Contract

- Payments:

\[
R^e_t = \frac{b}{\Delta \alpha}; \quad R^b_t = \frac{\mu}{q_t \Delta \alpha}; \quad R^h_t = R - \frac{b}{\Delta \alpha} - \frac{\mu}{q_t \Delta \alpha}
\]

where \( \Delta \alpha \equiv \alpha^g - \alpha^b > 0 \)

- Investment Size:

\[
i_t = \underbrace{(1/G_t)}_{\text{‘entrepreneurial leverage’}} \cdot \underbrace{a_t + n_t}_{\text{internal funds}}
\]

where

\[
G_t \equiv 1 + \mu - \frac{q_t \alpha^g}{1 + r^d_t} \left( R - \frac{b}{\Delta \alpha} - \frac{\mu}{\Delta \alpha q_t} \right)
\]
Law of motion of bank capital & entrepreneurial net worth

- Bank Capital (Bank equity or Bank net worth)
  - Build bank capital mainly from retained earnings

\[
A_{t+1} = (1 + \hat{r}_t) \tau^b q_t \alpha^g R_t^b \left( \frac{A_t + N_t}{G_t} \right) + w_{t+1}^b \eta^b
\]

- Entrepreneurial Net Worth

\[
N_{t+1} = (1 + \hat{r}_t) \tau^e q_t \alpha^g R_t^e \left( \frac{A_t + N_t}{G_t} \right) + w_{t+1}^e \eta^e
\]
### Table 1: Baseline Parameter Calibration

<table>
<thead>
<tr>
<th>Household Preferences and Wage Setting</th>
<th>( \gamma )</th>
<th>( \zeta )</th>
<th>( \psi )</th>
<th>( \beta )</th>
<th>( \xi_w )</th>
<th>( \phi_w )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.65</td>
<td>0.027</td>
<td>4.0</td>
<td>0.99</td>
<td>21</td>
<td>0.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capital Good Production and Financing</th>
<th>( \mu )</th>
<th>( \alpha^g )</th>
<th>( \alpha^b )</th>
<th>( R )</th>
<th>( b )</th>
<th>( \tau_e )</th>
<th>( \tau_b )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.025</td>
<td>0.99</td>
<td>0.75</td>
<td>1.21</td>
<td>0.16</td>
<td>0.78</td>
<td>0.72</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resulting Steady-State Characteristics</th>
<th>( CAR )</th>
<th>( I/N )</th>
<th>( BOC )</th>
<th>( ROE )</th>
<th>( I/Y )</th>
<th>( K/Y )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14%</td>
<td>2.0</td>
<td>5%</td>
<td>15%</td>
<td>0.198</td>
<td>11.8</td>
</tr>
</tbody>
</table>
Preview of Results

- Shock to technology (intermediate good production)

- Model Simulation
One Standard Deviation Adverse Technology Shock

Aggregate Output

Bank Capital–Asset Ratio

Entrepreneurial Leverage (I/N)

Short Term Rate

Aggregate Investment

Bank Net Worth

Entrepreneurial Net Worth

Inflation

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Banking Net Worth in the Transmission of a Negative Technology Shock

Aggregate Output

Aggregate Investment

Bank Capital–Asset Ratio

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Short Term Rate

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Baseline

Unchanged Bank Net Worth
Negative Shock to Bank Capital

Bank Capital–Asset Ratio

Entrepreneurial Leverage (I/N)

Aggregate Output

Aggregate Investment

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Short Term Rate

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## Cyclical Features: Model and Data

### Cross-Correlation of Net Worth to Asset with:

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\frac{\sigma(X)}{\sigma(GDP)}$</th>
<th>$X_{t-2}$</th>
<th>$X_{t-1}$</th>
<th>$X_t$</th>
<th>$X_{t+1}$</th>
<th>$X_{t+2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Worth to Asset Ratio</td>
<td>1.49</td>
<td>0.61</td>
<td>0.85</td>
<td>1.00</td>
<td>0.85</td>
<td>0.61</td>
</tr>
<tr>
<td>Investment</td>
<td>3.63</td>
<td>0.31</td>
<td>0.06</td>
<td>-0.22</td>
<td>-0.44</td>
<td>-0.59</td>
</tr>
<tr>
<td>GDP</td>
<td>1.00</td>
<td>0.11</td>
<td>-0.17</td>
<td><strong>0.46</strong></td>
<td>-0.65</td>
<td>-0.73</td>
</tr>
<tr>
<td>Bank Loans</td>
<td>3.75</td>
<td>0.20</td>
<td>-0.07</td>
<td>-0.36</td>
<td>-0.53</td>
<td>-0.64</td>
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<tr>
<td><strong>Panel B: Data</strong></td>
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<tr>
<td>Net Worth to Asset Ratio</td>
<td>0.34</td>
<td>0.79</td>
<td>0.90</td>
<td>1.00</td>
<td>0.90</td>
<td>0.79</td>
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<tr>
<td>Investment</td>
<td>4.26</td>
<td>-0.45</td>
<td>-0.42</td>
<td>-0.36</td>
<td>-0.25</td>
<td>-0.17</td>
</tr>
<tr>
<td>GDP</td>
<td>1.00</td>
<td>-0.36</td>
<td>-0.31</td>
<td>-0.23</td>
<td>-0.12</td>
<td>-0.07</td>
</tr>
<tr>
<td>Bank Loans (C &amp; I)</td>
<td>4.52</td>
<td>-0.52</td>
<td>-0.62</td>
<td>-0.70</td>
<td>-0.69</td>
<td>-0.67</td>
</tr>
</tbody>
</table>
Conclusion

- We present a quantitative model of aggregate fluctuations in which the net worth of banks mitigates an agency problem between banks and depositors.

- The cyclical features of the net worth to asset ratio of banks generated by the model are consistent with those observed in data.

- The presence of the dynamics of bank capital plays an important role in the transmission of shocks.
Our Model: Net Worth to Asset Ratio is market determined

Can be brought to bear on policy discussions: how should bank net worth to asset ratio react to shocks?
Future Work

• Interaction between market and regulatory discipline on banks

• Endogenous external bank equity (eg., Jermann & Quadrini, 2008).
Timing of Events Within a Period

- Technology shock is realized
- Households make consumption and investment decisions
- Stocks of capital $k^b_t$, $k^e_t$, $k^h_t$
- Final good production
- Households, banks and entrepreneurs agree to finance projects
- Returns are realized (public)
- Returns are shared between the 3 agents
- Period $t$

(1) Banks choose whether or not to monitor
(2) Entrepreneurs choose which project to undertake

Entrepreneurs and bankers consume and invest

Households, banks and entrepreneurs agree to finance projects

- Returns are realized (public)
- Returns are shared between the 3 agents
Banking Net Worth in the Transmission of a Monetary Tightening

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