Financial Intermediaries, Credit Shocks and Business Cycles
Yasin Mimir (Working Paper - JMP - 2012)

Omar Rachedi
Outline

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Empirical Evidence

The Model

Quantitative Results
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Quantitative Results

Summary
Motivation

- Credit frictions are crucial in understanding output fluctuations.
- Importance of financial intermediaries as propagation of cycles.
- What are the cyclical properties of financial flows in the U.S. banking sector?
- How important are banks’ financial shocks source of business cycles in the U.S.?
Contribution

- Gertler and Karadi (2011): **Financial intermediation** + frictions $\rightarrow$ business cycle.
- Empirical evidence on Bank Assets, Deposit, Net Worth, Leverage and Spreads.
- Quantitative analysis of banks **credit friction** and **financial shocks**:
  - Affect dynamics of standard macro variables.
  - Source of fluctuations.
Economic Mechanism

- Financial frictions → banks endogenous capital constraint in obtaining deposits → need equity to attract deposits.

- Shocks to bank net worth alter banks ability to borrow and extend loans to firms.

- Financial shocks → net worth → deposits → credit to firm.

- Credit → capital expenditure → labor hired → output.
Economic Mechanism

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- Credit → capital expenditure → labor hired → output.
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Data

- Assets and Liabilities of U.S. Commercial Banks.
- Assets are bank credit at the asset side of the balance sheet of the U.S. commercial banks.
- Liabilities are deposits held at the U.S. commercial banks.
- Net Worth is Asset - Deposits

<table>
<thead>
<tr>
<th>Asset</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset (Credit)</td>
<td>Debt (Deposits)</td>
</tr>
<tr>
<td></td>
<td>Equity (Net Worth)</td>
</tr>
</tbody>
</table>

- Loan spread is the spread between return to capital and deposit rate.
Figure 1: Financial Flows in the U.S. Economy
### Descriptive Statistics

Table 1: Business Cycle Properties of Real and Financial Variables, Quarterly U.S. Data, 1987-2010

<table>
<thead>
<tr>
<th></th>
<th>Standard Deviation</th>
<th>$x_{t-4}$</th>
<th>$x_{t-3}$</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>
<th>$x_{t+3}$</th>
<th>$x_{t+4}$</th>
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<tbody>
<tr>
<td><strong>Real Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1.80</td>
<td>0.15</td>
<td>0.39</td>
<td>0.66</td>
<td>0.87</td>
<td>1.00</td>
<td>0.87</td>
<td>0.66</td>
<td>0.39</td>
<td>0.15</td>
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<tr>
<td>Consumption</td>
<td>0.45</td>
<td>-0.20</td>
<td>0.06</td>
<td>0.37</td>
<td>0.66</td>
<td><strong>0.82</strong></td>
<td>0.80</td>
<td>0.67</td>
<td>0.46</td>
<td>0.25</td>
</tr>
<tr>
<td>Investment</td>
<td>2.73</td>
<td>0.27</td>
<td>0.49</td>
<td>0.71</td>
<td>0.87</td>
<td><strong>0.97</strong></td>
<td>0.82</td>
<td>0.59</td>
<td>0.33</td>
<td>0.09</td>
</tr>
<tr>
<td>Hours</td>
<td>0.91</td>
<td>-0.01</td>
<td>0.19</td>
<td>0.43</td>
<td>0.65</td>
<td>0.83</td>
<td><strong>0.89</strong></td>
<td>0.83</td>
<td>0.68</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Financial Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank credit</td>
<td>0.93</td>
<td>-0.20</td>
<td>-0.11</td>
<td>0.02</td>
<td>0.14</td>
<td>0.30</td>
<td>0.47</td>
<td>0.63</td>
<td><strong>0.68</strong></td>
<td>0.63</td>
</tr>
<tr>
<td>Deposits</td>
<td>0.69</td>
<td>-0.02</td>
<td>-0.08</td>
<td>-0.18</td>
<td>-0.30</td>
<td><strong>-0.42</strong></td>
<td>-0.34</td>
<td>-0.22</td>
<td>-0.07</td>
<td></td>
</tr>
<tr>
<td>Net Worth</td>
<td>5.17</td>
<td>-0.15</td>
<td>-0.03</td>
<td>0.14</td>
<td>0.32</td>
<td>0.52</td>
<td>0.70</td>
<td><strong>0.80</strong></td>
<td>0.76</td>
<td>0.63</td>
</tr>
<tr>
<td>Leverage Ratio</td>
<td>5.61</td>
<td>0.16</td>
<td>0.05</td>
<td>-0.12</td>
<td>-0.30</td>
<td>-0.49</td>
<td>-0.66</td>
<td><strong>-0.74</strong></td>
<td>-0.70</td>
<td>-0.55</td>
</tr>
<tr>
<td>Loan Spread</td>
<td>0.08</td>
<td>0.05</td>
<td>0.04</td>
<td>-0.08</td>
<td>-0.21</td>
<td>-0.39</td>
<td>-0.42</td>
<td><strong>-0.43</strong></td>
<td>-0.32</td>
<td>-0.18</td>
</tr>
</tbody>
</table>

- Business cycle statistics in the table are based on HP-filtered cyclical components of quarterly empirical time series (smoothing parameter: 1600).
- The standard deviation of output is expressed in percent; standard deviations of the remaining variables are normalized by the standard deviation of output (std(x)/std(GDP)).
- The correlation coefficients in bold font are the maximum ones in their respective rows.
- Data sources are provided in Appendix A.
- Assets (bank credit), liabilities (deposits), net worth, leverage ratio and loan spread. Quarterly seasonally-adjusted financial data are taken from the Federal Reserve Board. Quarterly real data are taken from Federal Reserve Economic Data (FRED) of St. Louis FED. Financial data at the FED Board is nominal. GDP deflator from NIPA accounts is used to deflate the financial time series. See the data appendix for a more detailed description.

Table 1 gives us the following empirical facts about real and financial variables. Consumption and hours are less volatile than output, while investment is more volatile; and consumption, investment, and hours are all strongly procyclical with respect to output. These are standard business-cycle facts; for example, see King and Rebelo (1999). Bank credit, deposits, and loan spread are less volatile than output, while net worth and leverage ratio are more volatile. Bank assets and net worth are procyclical, while deposits, leverage ratio, and loan spread are countercyclical. Finally, all financial variables lead the output fluctuations by one to three quarters.
• Bank credit, deposits and loan spread are less volatile than output, while net worth and leverage ratio are more volatile.

• Bank credit and net worth are procyclical, while deposits, leverage ratio and loan spread are countercyclical.

• Financial variables lead the output fluctuations by one to three quarters.
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Summary
Environmental

- Four types of agents: households, financial intermediaries (FIs), firms, and capital producers.
- The ability of financial intermediaries to borrow from households is limited due to a moral hazard (costly enforcement) problem.
- Firms acquire capital by selling shares to financial intermediaries.
- Capital producers → capital adjustment costs.
Households

- Continuum of households: consume and work in firms.
- Save by holding deposits at FIs → riskless return $r_t$
- Two types of members in each household: workers and bankers.
- Workers supply labor and return wages to household.
- Bankers manage bank and return profits to household.
- Deposits of the household in bank it does not own.
- Perfect consumption insurance within each household.
Households

- 1 – \( \zeta \) household members are bankers. \( \zeta \) are workers.
- Banker has probability \( \theta \) to become worker.
- Budget constraint

\[
c_t + db = w_t L_t + (1 + r_t) d_t + \Pi_t
\]

\[
U_t(t) = wU_c(t)
\]

\[
U_c(t+1) = \beta (1 + r_{t+1}) E_t [U_c(t+1)]
\]
Continuum \( j \in [0, 1 - \zeta] \) of FIs. Each FI has:

- **deposit** from household \( d_{jt+1} \rightarrow \text{return riskless } r_{t+1} \)
- **firms equity** \( q_t s_{jt} \rightarrow \text{return } r_{kt+1} \)
- **net-worth** \( n_{jt} = \omega_{jt} \tilde{n}_{jt}. \text{ Financial shock } \omega. \)

Balance sheet

\[
q_t s_{jt} = d_{jt+1} + n_{jt}
\]

Law of motion of bank net worth

\[
\tilde{n}_{jt+1} = \underbrace{(r_{kt+1} - r_{t+1}) q_t s_{jt}}_{\text{Risk Premium}} + (1 + r_{t+1}) n_{jt}
\]
FIs - Balance Sheet

- Continuum $j \in [0, 1 - \xi]$ of FIs. Each FI has:
  - **deposit** from household $d_{jt+1} \rightarrow$ return riskless $r_{t+1}$
  - **firms equity** $q_t s_{jt} \rightarrow$ return $r_{kt+1}$
  - **net-worth** $n_{jt} = \omega_{jt} \hat{n}_{jt}$. Financial shock $\omega$.

- Balance sheet
  $$q_t s_{jt} = d_{jt+1} + n_{jt}$$

- Law of motion of bank net worth
  $$\hat{n}_{jt+1} = \underbrace{(r_{kt+1} - r_{t+1}) q_t s_{jt}}_{\text{Risk Premium}} + (1 + r_{t+1}) n_{jt}$$
FIs - Profit Maximization

- FIs maximize expected discount net-worth choosing firm shares $s_{jt}$

$$V_{jt} = \max_{s_{jt}} E_t \sum_{i=0}^{\infty} (1 - \theta) \theta^i \beta^{i+1} \Lambda_{t,t+1+i} [(r_{kt+1+i} - r_{t+1+i}) q_{t+i} s_{jt+i} + (1 + r_{t+1+i}) n_{jt+i}]$$

- If risk premium is positive $\rightarrow$ buy shares.

- **Agency problem**: banker can divert a fraction $\lambda$ of funds

$$V_{jt} \geq \lambda q_t s_{jt}$$
FIs - Leverage and Net Worth

- Proposition 1:

\[ V_{jt} = \nu_t q_t s_t + \eta_t n_t \]
\[
\nu_t = E_t [(1 - \theta) \beta] \Lambda_{t,t+1} (r_{kt+1} - r_{t+1}) + \beta \Lambda_{t,t+1} \theta \frac{q_{t+1} s_{jt+1}}{q_t s_{jt}} 
\]
\[
\eta_t = E_t [(1 - \theta) \beta] \Lambda_{t,t+1} (1 + r_{t+1}) + \beta \Lambda_{t,t+1} \theta \frac{n_{jt+1}}{n_{jt}} \eta_{t+1} 
\]

- \( \nu_t \): expected discounted mg gain buying one more share.
- \( \eta_t \): expected discounted mg gain having one more unit of net worth.
FIs - Leverage and Net Worth

- Incentive compatibility becomes $\nu_t q_t s_{jt} + \eta_t n_{jt} \geq \lambda q_t s_{jt}$
- Proposition 2: The constraint binds as long as $0 < \nu_t < \lambda$
- **Proposition 3**: Risk premium is positive as long as the incentive compatibility binds.
- Proposition 4: Banks are identical (linear world).

- Leverage
  \[
  \frac{d_{t+1}}{n_t} = \frac{\eta_t}{\lambda - \nu_t} - 1
  \]
- Demand for equity
  \[
  q_t s_t = \frac{\eta_t}{\lambda - \nu_t} n_t
  \]
Firms

- Continuum of firms produce final output \( Y_t = z_t K_t^\alpha H_t^{1-\alpha} \)

  - **Period t**: Acquire capital \( K_{t+1} \)
  
  - **Period t+1**: Hire labor, produce and sell depreciated capital.

- Capital expenditures funded by equity sold to FIs. No frictions.

- Issue \( s_t \) units of equity to buy \( K_{t+1} \)

\[
q_t s_t = q_t K_{t+1}
\]

- Ex-post return to capital

\[
r_{kt+1} = \frac{z_{t+1} F_K (K_{t+1}, H_{t+1}) + q_{t+1} (1 - \delta)}{q_t} - 1
\]
Capital Producers

- Introduce variations in price of capital $\rightarrow$ Financial Accelerator
- Owned by households.
- At end period $t$, buy capital from firms $\rightarrow$ new capital sold to firms

$$\max_{l_t} q_t K_{t+1} - q_t (1 - \delta) K_t - l_t$$

s.t. $K_{t+1} = (1 - \delta) K + \Phi \left( \frac{l_t}{K_t} \right) K_t$

$$q_t = \left[ \Phi' \left( \frac{l_t}{K_t} \right) \right]^{-1}$$
### The Model

#### Timing

1. Productivity $z_t$ is realized.
2. Firms hire labor $H_t$ and use capital $K_t$ they purchased in period $t - 1$, which are used for production, $Y_t = z_t F(K_t, H_t)$.
3. Firms make their wage payments $w_t H_t$ and dividend payments to shareholders (banks) from period $t-1$.
4. Banks make their interest payments on deposits of households from period $t-1$ and bankers exit with probability $(1-\theta)$.
5. Recovery rate $\omega_t$ is realized.
6. Households make their consumption and saving decisions and deposit their resources at banks.
7. Firms sell their depreciated capital to capital producers. These agents make investment and produce new capital $K_{t+1}$.
8. Firms issue shares [$s_t = K_{t+1}$] and sell these shares to banks to finance their capital expenditures.
10. Firms purchase capital $K_{t+1}$ from capital producers at the price of $q_t$ with borrowed funds.
Credit Friction and Long-Run Equilibrium

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Credit Friction and Long-Run Equilibrium

The bottom panels plot the innovations $\epsilon_{z,t}$ and $\epsilon_{\omega,t}$. These innovations are unexpected changes in the levels of productivity and financial conditions. The plots suggest that the U.S. economy is severely hit by both negative productivity and financial shocks in the Great Recession.

Figure 3: Long-run equilibrium as a function of fraction of diverted funds by bankers

4.2 Long-Run Equilibrium of the Model

This section presents the deterministic steady-state properties of the model economy. First, I will formally show how the tightness of bank capital constraints affects output. Imposing the steady-state on the competitive equilibrium condition of the model economy yields the following analytical expression for output:

$$y = \left[\frac{\alpha(1-\beta\theta)\mu}{\lambda(1-\theta)\beta(1+\mu)} + (1-\beta)\delta\right]^{1/(1-\alpha)}L^2 - \alpha(39)$$

where $\mu$ is the Lagrange multiplier of bank capital constraint. Taking the partial derivative of output w.r.t. $\mu$, I obtain...
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Table 3: Model Parameterization and Calibration

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
<th>Data</th>
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</thead>
<tbody>
<tr>
<td><strong>Preferences</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quarterly discount factor</td>
<td>$\beta$</td>
<td>0.9942</td>
<td>Annualized real deposit rate</td>
<td>2.37%</td>
</tr>
<tr>
<td>Relative utility weight of leisure</td>
<td>$\nu$</td>
<td>1.7167</td>
<td>Hours worked</td>
<td>0.3333</td>
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<tr>
<td><strong>Production Technology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of capital in output</td>
<td>$\alpha$</td>
<td>0.36</td>
<td>Labor share of output</td>
<td>0.64</td>
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<tr>
<td>Capital adjustment cost parameter</td>
<td>$\varphi$</td>
<td>3.6</td>
<td>Relative volatility of price of investment</td>
<td>0.37</td>
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<tr>
<td>Depreciation rate of capital</td>
<td>$\delta$</td>
<td>0.025</td>
<td>Average annual ratio of investment to capital</td>
<td>10%</td>
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<tr>
<td>Steady-state total factor productivity</td>
<td>$\tau$</td>
<td>1</td>
<td>Normalization</td>
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<tr>
<td><strong>Financial Intermediaries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady-state fraction of assets that can be diverted</td>
<td>$\lambda$</td>
<td>0.1548</td>
<td>Commercial and industrial loan spread</td>
<td>0.46%</td>
</tr>
<tr>
<td>Proportional transfer to the entering bankers</td>
<td>$\epsilon$</td>
<td>0.001</td>
<td>0.1% of aggregate net worth</td>
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<tr>
<td>Survival probability of the bankers</td>
<td>$\theta$</td>
<td>0.9685</td>
<td>Leverage ratio of commercial banks</td>
<td>4.62</td>
</tr>
<tr>
<td>Steady-state level of net worth shock</td>
<td>$\omega$</td>
<td>1</td>
<td>Normalization</td>
<td>N/A</td>
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<tr>
<td><strong>Shock Processes</strong></td>
<td></td>
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<tr>
<td>Persistence of TFP process</td>
<td>$\rho_z$</td>
<td>0.9315</td>
<td>Quarterly persistence of TFP process</td>
<td>0.9315</td>
</tr>
<tr>
<td>Standard deviation of productivity shock</td>
<td>$\sigma_z$</td>
<td>0.006424</td>
<td>Quarterly standard dev. of TFP shock</td>
<td>0.0064</td>
</tr>
<tr>
<td>Persistence of $\omega$ process</td>
<td>$\rho_\omega$</td>
<td>0.3744</td>
<td>Quarterly persistence of $\omega$ process</td>
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<tr>
<td>Standard deviation of net worth shock</td>
<td>$\sigma_\omega$</td>
<td>0.0512</td>
<td>Quarterly standard dev. of net worth shock</td>
<td>0.0512</td>
</tr>
</tbody>
</table>
Net Worth Shocks

- As Jermann and Quadrini (2012), net worth shocks computed as residuals.
- Constructed from the law of motion for bank net worth

\[ \omega_t = \frac{1}{\theta \left[ (r_{kt+1} - r_{t+1}) \frac{\eta_t}{\lambda - \nu_t} + (1 + r_{t+1}) \right]} \frac{\tilde{n}_{t+1}}{\tilde{n}_t} \]

- Using data over 1987Q1-2010Q4, estimation of

\[ \log(\omega_{t+1}) = \rho_\omega \log(\omega_t) + \varepsilon_{t+1}^\omega \]
IRFs Productivity Shock

Figure 4: Impulse responses to a negative one-standard-deviation productivity shock.
IRFs Net Worth Shock

Figure 5: Impulse responses to a negative one-standard-deviation net worth shock.
Summary Results

Table 4: Real and Financial Statistics

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Data</th>
<th>RBC</th>
<th>Only Productivity</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sigma_Y )</td>
<td>1.80</td>
<td>1.44</td>
<td>1.53</td>
<td>1.81</td>
</tr>
<tr>
<td>( \sigma_C )</td>
<td>0.45</td>
<td>0.41</td>
<td>0.39</td>
<td>0.75</td>
</tr>
<tr>
<td>( \sigma_I )</td>
<td>2.73</td>
<td>2.45</td>
<td>2.98</td>
<td>4.64</td>
</tr>
<tr>
<td>( \sigma_L )</td>
<td>0.91</td>
<td>0.40</td>
<td>0.46</td>
<td>0.84</td>
</tr>
<tr>
<td>( \rho_{Y,I} )</td>
<td>0.97</td>
<td>1.00</td>
<td>0.98</td>
<td>0.87</td>
</tr>
<tr>
<td>( \rho_{Y,C} )</td>
<td>0.82</td>
<td>0.97</td>
<td>0.85</td>
<td>-0.03</td>
</tr>
<tr>
<td>( \rho_{Y,L} )</td>
<td>0.83</td>
<td>0.99</td>
<td>0.96</td>
<td>0.81</td>
</tr>
<tr>
<td>( \sigma_{Assets} )</td>
<td>0.93</td>
<td>–</td>
<td>0.40</td>
<td>0.58</td>
</tr>
<tr>
<td>( \sigma_{Deposits} )</td>
<td>0.69</td>
<td>–</td>
<td>0.39</td>
<td>0.87</td>
</tr>
<tr>
<td>( \sigma_{NetWorth} )</td>
<td>5.17</td>
<td>–</td>
<td>1.36</td>
<td>5.90</td>
</tr>
<tr>
<td>( \sigma_{LeverageR.} )</td>
<td>5.61</td>
<td>–</td>
<td>1.40</td>
<td>6.40</td>
</tr>
<tr>
<td>( \sigma_{Spread} )</td>
<td>0.08</td>
<td>–</td>
<td>0.07</td>
<td>0.23</td>
</tr>
<tr>
<td>( \rho_{Y,Assets} )</td>
<td>0.30</td>
<td>–</td>
<td>0.90</td>
<td>0.88</td>
</tr>
<tr>
<td>( \rho_{Y,Deposits} )</td>
<td>-0.39</td>
<td>–</td>
<td>0.46</td>
<td>-0.23</td>
</tr>
<tr>
<td>( \rho_{Y,NetWorth} )</td>
<td>0.52</td>
<td>–</td>
<td>0.87</td>
<td>0.68</td>
</tr>
<tr>
<td>( \rho_{Y,LeverageR.} )</td>
<td>-0.49</td>
<td>–</td>
<td>-0.71</td>
<td>-0.59</td>
</tr>
<tr>
<td>( \rho_{Y,Spread} )</td>
<td>-0.39</td>
<td>–</td>
<td>-0.86</td>
<td>-0.67</td>
</tr>
</tbody>
</table>
Summary

- **Financial intermediation** + frictions $\rightarrow$ business cycle.
- Empirical evidence on Bank Assets, Deposit, Net Worth, Leverage and Spreads.
- Quantitative analysis of banks **financial shocks** and **credit friction**:  
  - Affect dynamics of standard macro variables.
  - Source of fluctuations.