Incorporate Financial Frictions into a Business Cycle Model

• General idea:
  – Standard model assumes borrowers and lenders are the same people..no conflict of interest
  – Financial friction models suppose borrowers and lenders are different people, with conflicting interests
  – Financial frictions: features of the relationship between borrowers and lenders adopted to mitigate conflict of interest.
Backyard capital accumulation: \( K_{t+1} = (1 - \delta)K_t + G(I_t, I_{t-1}) \)

Savers and investors are the same: NO FRICTIONS!

\[
\begin{align*}
    u_{c,t} &= \beta E_t u_{c,t+1} \frac{r^k_{t+1} + (1 - \delta)P_{k',t+1}'}{P_{k',t}} \\
\end{align*}
\]
Frictions in Financing of Physical Capital

Savers
Have money, but no ideas

Investors ('entrepreneurs')
Have ideas, but not enough money.

Money
Frictions in Financing of Physical Capital

Money

Savers
Have money, but no ideas

Investors ('entrepreneurs')
Problem: ‘stuff’ happens.

Incentive of entrepreneurs to under-report earnings
A Very Simple Two-Period Model to Get at the Basic Idea


• Also, Christiano, Motto, Rostagno, 2003, The Great Depression and the Friedman-Schwartz Hypothesis.
• Period 1
  – No uncertainty
  – Households face leisure-work choice and buy bonds from a bank, with state-non contingent interest.
  – Entrepreneurs own equal share of capital, $k$, in first period, and apply income and loans from bank to buy capital for use in period 2. Experience an idiosyncratic productivity shock.

• Period 2
  – Aggregate uncertainty
  – Entrepreneurs pay back loans from banks, which repay households.
Households

- Household preferences

\[ U(c, l) + \pi U(c^h, l^h) + (1 - \pi)U(c^l, l^l). \]

- Budget constraints

\[ c + B \leq w_l, \]
\[ c^h \leq w^h l^h + RB, \]
\[ c^l \leq w^l l^l + RB. \]

- Euler equations:

\[ -\frac{U_l}{U_c} = w, \quad -\frac{U^h_l}{U^h_c} = w^h, \quad -\frac{U^l_l}{U^l_c} = w^l \]

\[ 1 = \beta \left[ \pi \frac{U^h_c}{U^h_c} + (1 - \pi) \frac{U^l_c}{U^l_c} \right] R, \]
Goods-producing firms

• Technology:

\[ y = F(k, l) \]
\[ y^h = F^h(K, l^h) \]
\[ y^l = F^l(K, l^l) \]

• Competition ensures:

\[ w = F_1(k, l), \quad w^h = F^h_1(K, l^h), \quad w^l = F^l_1(K, l^l) \]
\[ r = F_k(k, l), \quad r^h = F^h_k(K, l^h), \quad r^l = F^l_k(K, l^l) \]
Entrepreneurs

• In period 1, each owns equal share of capital stock, $k$

• Net worth at end of period, $N=rk$ (100% $k$ depreciation)

• Entrepreneurs borrow $K-N$ from banks at end of period 1, and banks get the money by issuing bonds, $B$, to households.
Idiosyncratic uncertainty

• After purchasing $K$, entrepreneurs experience idiosyncratic shock:

\[ K \rightarrow \omega K, \ \omega \sim F(\omega), \ E\omega = 1. \]

• Standard debt contract

\[ \omega > \bar{\omega}^h \rightarrow \text{pay } \bar{\omega}^h r^h K \text{ to bank} \]

\[ \omega < \bar{\omega}^h \rightarrow \text{pay } \omega r^h K \text{ to bank, bank pays } \mu \omega r^h K \text{ in monitoring costs} \]
Standard Debt Contract, cnt’d

\( \omega > \bar{\omega} \) → pay \( \bar{\omega} r^l K \) to bank

\( \omega < \bar{\omega} \) → pay \( \omega r^l K \) to bank, bank pays \( \mu \omega r^l K \) in monitoring costs

- Parameters of Standard Debt Contract:

  \( \bar{\omega}^h, \bar{\omega}^l \) and \( K \)
Determination of Parameters of Standard Debt Contract

• Expected utility of entrepreneur at start of contract:

\[ \pi \times r^h K + (1 - \pi) [1 - \Gamma^l] r^l K, \]

share of gross entrepreneurial earnings in state \( h \) kept by entrepreneur

\[ \Gamma^h = \int_{0}^{\bar{\omega}^h} \omega dF(\omega) + \bar{\omega}^h \int_{\bar{\omega}^h}^{\infty} dF(\omega) \]

share of gross earnings of entrepreneur taken by bank

\[ \Gamma^l = \int_{0}^{\bar{\omega}^l} \omega dF(\omega) + \bar{\omega}^l \int_{\bar{\omega}^l}^{\infty} dF(\omega) \]
Contract

• Competition among banks ensures zero profits for the banks.
  – Zero profit condition represents a ‘menu’ of contracts, with different interest rates and loan amounts.

• Contract which trades in equilibrium is the one entrepreneurs most prefer.

\[
\max_{\tilde{\omega}(s), K} \pi \left[ 1 - \Gamma^h \right] r^h K + (1 - \pi) \left[ 1 - \Gamma^l \right] r^l K \\
+ \lambda^h \{[\Gamma^h - \mu G^h] r^h K - [K - N] R \} \\
+ \lambda^l \{[\Gamma^l - \mu G^l] r^l K - [K - N] R \},
\]

\[
G(\tilde{\omega}(s)) = \int_0^{\tilde{\omega}(s)} \omega f(\omega) \, d\omega.
\]
Characterizing Equilibrium Contract

• First order condition for $K$ ($K-N$ is loan amount)

$$
\pi [1 - \Gamma^h] r^h + (1 - \pi) [1 - \Gamma^l] r^l
+ \lambda^h \{[\Gamma^h - \mu G^h] r^h - R\} + \lambda^l \{[\Gamma^l - \mu G^l] r^l - R\}
$$

• First order condition for $\bar{\omega}^h$ and $\bar{\omega}^l$:

$$
\lambda^h = \frac{\pi \Gamma''^h}{\Gamma''^h - \mu G''^h}
$$

$$
\lambda^l = \frac{(1 - \pi) [1 - \Gamma''^l]}{\Gamma''^l - \mu G''^l}.
$$
Equations Characterizing Contract:

• Optimality:

\[
\pi[1 - \Gamma^h] r^h + (1 - \pi)[1 - \Gamma^l] r^l \\
+ \frac{\pi \Gamma'^h}{\Gamma'^h - \mu G'^h} \{[\Gamma^h - \mu G^h] r^h - R\} + \frac{(1 - \pi)[1 - \Gamma'^l]}{\Gamma'^l - \mu G'^l} \{[\Gamma^l - \mu G^l] r^l - R\}
\]

• Competition (i.e., zero profits)

\[
[\Gamma^h - \mu G^h] r^h K = [K - N] R \\
[\Gamma^l - \mu G^l] r^l K = [K - N] R.
\]
Equilibrium

• Three equations for loan contract (optimality and competition)

• Resource constraints:

\[ c + K \leq F(k, l) \]

\[ \begin{aligned}
& c^h + \mu G(\bar{\omega}^h) r^h K + [1 - \Gamma^h] r^h K \leq F(K, l^h) \\
& c^l + \mu G(\bar{\omega}^l) r^l K + [1 - \Gamma^l] r^l K \leq F(K, l^l)
\end{aligned} \]

• Household and firm first order conditions:

\[ - \frac{U_l}{U_c} = F_l(k, l), \quad - \frac{U_l}{U_c} = F^h_l(K, l^h), \quad - \frac{U_l}{U_c} = F^l_l(K, l^l) \]

\[ 1 = \beta \left[ \pi \frac{U_h}{U_c} + (1 - \pi) \frac{U_l}{U_c} \right] R, \]
Equilibrium

- Ten equations in 10 unknowns:

\[ l, l^h, l^l, c, c^h, c^l, K, \bar{\omega}^h, \bar{\omega}^l, R \]
Incorporating BGG Financial Friction into a Monetary Model
Entrepreneurs (BGG)

- Own and Rent the Stock of Capital
- Period $t$:
  - Go to bank with own net worth and obtain loan
  - Purchase new capital from capital producers: $\bar{K}_{t+1}$
  - Experience an idiosyncratic productivity shock: $\omega \bar{K}_{t+1}, \omega \sim F(\omega; \sigma_t)$
- Period $t+1$:
  - Choose capital utilization rate and rent out capital services: $u_{t+1} \omega \bar{K}_{t+1}$
  - Cost of utilization: $\tau_{t+1}^{oil} a(u_{t+1}) \gamma^{-(t+1)} \omega \bar{K}_{t+1}$

$$V_{t+1} = \text{real earnings on capital (rent plus capital gains)}_t$$

$$V_{t+1} = \frac{\text{nominal rate of interest}}{\pi_t}^{t-1} \text{real debt to banks}_{t-1}$$

$$\text{Net Worth}_{t+1} = \gamma (V_{t+1} + W_{t+1}) + (1 - \gamma) W_{t+1}$$
Prediction of financial friction model:

• Shocks that drive output and price in the same direction (‘demand’) accelerated by financial frictions.
  – Fisher and earnings effects reinforce each other.

• Shocks that drive output and price in opposite directions (‘supply’) not much affected by financial frictions.
  – Fisher and earnings effects cancel each other.
Model with Financial Frictions

- Firms
  - Labor market
  - Household
  - Capital Producers
  - Entrepreneurs

Connections:
- \( L \): Labor market to Firms
- \( C \): Capital Producers to Firms
- \( I \): Firms to Capital Producers
- \( K \): Entrepreneurs to Firms
Model with Financial Frictions

- Firms
- Labor market
- Capital Producers
- Entrepreneurs
- Household
- Banks

- $K'$
- Loans
The equations of the financial friction model

• Net addition of two equations to consensus model:

  – Subtract the household intertemporal equation for capital.

  – Add three equations pertaining to the entrepreneurs
Three equations pertaining to entrepreneur

• Law of motion of net worth

• Zero-profit conditions of banks

\[
\text{revenues from non-bankrupt entrepreneurs} \times \text{quantity of non-bankrupt entrepreneurs} + \text{receipts from bankrupt entrepreneurs net of bankruptcy costs} = \text{payment obligations on bank debt to households}
\]

• Optimality condition associated with entrepreneur’s choice of contract.
Empirical Analysis of Financial Friction Model

Risk Shock and News

• Assume

\[ \hat{\sigma}_t = \rho_1 \hat{\sigma}_{t-1} + \underbrace{u_t}_{\text{iid, univariate innovation to } \hat{\sigma}_t} \]

• Agents have advance information about pieces of \( u_t \)

\[ u_t = \xi^0_t + \xi^1_{t-1} + \ldots + \xi^8_{t-8} \]

\[ \xi^i_{t-i} \sim \text{iid, } E(\xi^i_{t-i})^2 = \sigma^2_i \]

\[ \xi^i_{t-i} \sim \text{piece of } u_t \text{ observed at time } t - i \]
Estimation

• EA and US data covering 1985Q1-2007Q2

$$X_t = \begin{align*}
\Delta \log\left( \frac{N_{t+1}}{P_t} \right) \\
\pi_t \\
\log\text{(per capita hours)}_t \\
\Delta \log\left( \frac{\text{per capita credit}}{P_t} \right) \\
\Delta \log\text{(per capita GDP)}_t \\
\Delta \log\left( \frac{W_t}{P_t} \right) \\
\Delta \log\text{(per capita I)}_t \\
\Delta \log\left( \frac{\text{per capita } M1_t}{P_t} \right) \\
\Delta \log\left( \frac{\text{per capita } M3_t}{P_t} \right) \\
\Delta \log\text{(per capita consumption)}_t \\
\text{External Finance Premium}_t \\
R_{t}^{long} - R_{t}^{e} \\
R_{t}^{e} \\
\Delta \log P_{t,t} \\
\Delta \log\text{real oil price}_t \\
\Delta \log\left( \frac{\text{per capita Bank Reserves}}{P_t} \right)
\end{align*}$$

• Standard Bayesian methods
• We remove sample means from data and set steady state of X to zero in estimation.
Summary of Empirical Results With Financial Frictions

• Risk shocks:
  – important source of fluctuations.
  – news on the risk shock important

• The Fisher debt-deflation channel has a substantial impact on propagation.

• Money demand and mechanism of producing inside money:
  – relatively unimportant as a source of shocks
  – modest contribution to forecast ability

• Model accounts or substantial fraction of fluctuations in term structure.

• Out-of-Sample RMSEs of the model perform well compared with BVAR and simpler models.
Risk Shocks are Important

Actual data versus what actual data would have been if there were only risk shocks:

<table>
<thead>
<tr>
<th>Shocks</th>
<th>Euro Area</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riskiness, $\sigma$: whole process</td>
<td><img src="graph1.png" alt="Graph" /></td>
<td><img src="graph2.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

Note:
1. As suggested by the picture, risk shocks are relatively important at the lower frequencies.
2. We find that they are the single most important source of low frequency fluctuation in the EA, and a close second (after permanent tech shocks) in the US.
<table>
<thead>
<tr>
<th>shock</th>
<th>output</th>
<th>consumption</th>
<th>investment</th>
<th>hours</th>
<th>inflation</th>
<th>labor productivity</th>
<th>interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markup</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\lambda_f}$</td>
<td>15.02</td>
<td>23.05</td>
<td>2.63</td>
<td>16.37</td>
<td>35.74</td>
<td>1.40</td>
<td>20.46</td>
</tr>
<tr>
<td>Banking tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\lambda_b}$</td>
<td>0.59</td>
<td>1.29</td>
<td>0.02</td>
<td>0.44</td>
<td>0.52</td>
<td>1.44</td>
<td>0.24</td>
</tr>
<tr>
<td>Capital tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\delta}$</td>
<td>0.32</td>
<td>0.01</td>
<td>0.12</td>
<td>0.18</td>
<td>0.08</td>
<td>0.01</td>
<td>0.04</td>
</tr>
<tr>
<td>Money demand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_\chi$</td>
<td>0.02</td>
<td>0.06</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Government</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_g$</td>
<td>3.26</td>
<td>3.11</td>
<td>0.00</td>
<td>3.34</td>
<td>0.87</td>
<td>0.21</td>
<td>0.48</td>
</tr>
<tr>
<td>Permanent tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\delta^2}$</td>
<td>3.72</td>
<td>1.16</td>
<td>0.24</td>
<td>1.42</td>
<td>1.07</td>
<td>10.29</td>
<td>0.72</td>
</tr>
<tr>
<td>Gamma shock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_\gamma$</td>
<td>0.43</td>
<td>0.06</td>
<td>0.92</td>
<td>0.80</td>
<td>0.24</td>
<td>1.52</td>
<td>0.30</td>
</tr>
<tr>
<td>Temporary shock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_\epsilon$</td>
<td>10.54</td>
<td>21.68</td>
<td>0.49</td>
<td>7.46</td>
<td>16.10</td>
<td>27.52</td>
<td>8.56</td>
</tr>
<tr>
<td>Monetary policy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\epsilon^{policy}}$</td>
<td>6.22</td>
<td>11.27</td>
<td>1.01</td>
<td>4.14</td>
<td>5.40</td>
<td>0.10</td>
<td>33.15</td>
</tr>
<tr>
<td>Risk, contemp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_\sigma$</td>
<td>2.88</td>
<td>0.19</td>
<td>5.11</td>
<td>6.57</td>
<td>0.88</td>
<td>13.17</td>
<td>1.08</td>
</tr>
<tr>
<td>Signals on risk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\sigma^ signal}$</td>
<td>20.09</td>
<td>1.81</td>
<td>38.09</td>
<td>15.96</td>
<td>9.22</td>
<td>38.24</td>
<td>9.80</td>
</tr>
<tr>
<td>Risk and signals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_\sigma$ and $\sigma_{\sigma^ signal}$</td>
<td>22.96</td>
<td>2.00</td>
<td>43.20</td>
<td>22.53</td>
<td>10.09</td>
<td>51.41</td>
<td>10.88</td>
</tr>
<tr>
<td>Discount rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\xi_c}$</td>
<td>11.68</td>
<td>32.75</td>
<td>0.15</td>
<td>12.20</td>
<td>11.26</td>
<td>0.83</td>
<td>10.15</td>
</tr>
<tr>
<td>Marginal eff of l</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\xi_i}$</td>
<td>24.57</td>
<td>1.72</td>
<td>51.14</td>
<td>30.69</td>
<td>10.17</td>
<td>5.22</td>
<td>11.56</td>
</tr>
<tr>
<td>Price of oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\xi^{all}}$</td>
<td>0.42</td>
<td>1.39</td>
<td>0.03</td>
<td>0.24</td>
<td>2.21</td>
<td>0.04</td>
<td>1.32</td>
</tr>
<tr>
<td>Long rate error</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\xi long}$</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>measurement error</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.26</td>
</tr>
<tr>
<td>inflation target</td>
<td>0.24</td>
<td>0.43</td>
<td>0.05</td>
<td>0.16</td>
<td>6.23</td>
<td>0.01</td>
<td>0.87</td>
</tr>
<tr>
<td>all shocks</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Shock</td>
<td>Output</td>
<td>Consumption</td>
<td>Investment</td>
<td>Hours</td>
<td>Inflation</td>
<td>Labor Productivity</td>
<td>Interest Rate</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
<td>-------------</td>
<td>------------</td>
<td>-------</td>
<td>-----------</td>
<td>--------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>$\alpha_0$</td>
<td>2.88</td>
<td>0.19</td>
<td>5.11</td>
<td>6.57</td>
<td>0.88</td>
<td>13.17</td>
<td>1.08</td>
</tr>
<tr>
<td>$\alpha_{signal}$</td>
<td>20.09</td>
<td>1.81</td>
<td>38.09</td>
<td>15.96</td>
<td>9.22</td>
<td>38.24</td>
<td>9.80</td>
</tr>
<tr>
<td>$\alpha$ and $\alpha_{signal}$</td>
<td>22.96</td>
<td>2.00</td>
<td>43.20</td>
<td>22.53</td>
<td>10.09</td>
<td>51.41</td>
<td>10.88</td>
</tr>
<tr>
<td>All shocks</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Table: Variance Decomposition, HP filtered data, EA

<table>
<thead>
<tr>
<th>shock</th>
<th>stock market</th>
<th>credit spread</th>
<th>term structure</th>
<th>real M1</th>
<th>real M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markup</td>
<td>$\sigma_{\lambda_f}$</td>
<td>1.83</td>
<td>13.15</td>
<td>0.16</td>
<td>12.36</td>
</tr>
<tr>
<td>Banking tech</td>
<td>$\sigma_{x^b}$</td>
<td>0.00</td>
<td>0.14</td>
<td>0.00</td>
<td>0.10</td>
</tr>
<tr>
<td>Capital tech</td>
<td>$\sigma_{\mu_Y}$</td>
<td>0.18</td>
<td>0.07</td>
<td>0.03</td>
<td>0.07</td>
</tr>
<tr>
<td>Money demand</td>
<td>$\sigma_{\chi}$</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Government</td>
<td>$\sigma_g$</td>
<td>0.03</td>
<td>0.10</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>Permanent tech</td>
<td>$\sigma_{\mu_z}$</td>
<td>0.17</td>
<td>0.07</td>
<td>0.05</td>
<td>0.14</td>
</tr>
<tr>
<td>Gamma shock</td>
<td>$\sigma_{\gamma}$</td>
<td>5.37</td>
<td>25.82</td>
<td>1.86</td>
<td>0.33</td>
</tr>
<tr>
<td>Temporary tech</td>
<td>$\sigma_{\epsilon}$</td>
<td>0.10</td>
<td>4.06</td>
<td>0.00</td>
<td>3.40</td>
</tr>
<tr>
<td>Monetary policy</td>
<td>$\sigma_{\text{policy}}$</td>
<td>4.89</td>
<td>1.81</td>
<td>0.99</td>
<td>25.76</td>
</tr>
<tr>
<td>Risk, contemp</td>
<td>$\sigma_{\sigma}$</td>
<td>13.94</td>
<td>5.07</td>
<td>20.58</td>
<td>0.97</td>
</tr>
<tr>
<td>Signals on risk</td>
<td>$\sigma_{\sigma_{\text{signal}}}$</td>
<td>68.29</td>
<td>44.23</td>
<td>75.90</td>
<td>6.79</td>
</tr>
<tr>
<td>Risk and signals</td>
<td>$\sigma_{\sigma}$ and $\sigma_{\sigma_{\text{signal}}}$</td>
<td>82.22</td>
<td>49.30</td>
<td>96.48</td>
<td>7.76</td>
</tr>
<tr>
<td>Discount rate</td>
<td>$\sigma_{\xi_c}$</td>
<td>0.02</td>
<td>1.72</td>
<td>0.02</td>
<td>3.99</td>
</tr>
<tr>
<td>Marginal eff of I</td>
<td>$\sigma_{\xi_i}$</td>
<td>1.90</td>
<td>2.54</td>
<td>0.27</td>
<td>8.77</td>
</tr>
<tr>
<td>Price of oil</td>
<td>$\sigma_{\xi_{\text{oil}}}$</td>
<td>0.14</td>
<td>0.94</td>
<td>0.05</td>
<td>0.56</td>
</tr>
<tr>
<td>Error in long rate</td>
<td>$\sigma_{\text{long}}$</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>36.05</td>
</tr>
<tr>
<td>measurement error</td>
<td>2.89</td>
<td>0.19</td>
<td>0.02</td>
<td>0.32</td>
<td>0.21</td>
</tr>
<tr>
<td>inflation target</td>
<td>0.24</td>
<td>0.10</td>
<td>0.05</td>
<td>0.34</td>
<td>0.35</td>
</tr>
<tr>
<td>all shocks</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>$\sigma$</td>
<td>stock market</td>
<td>credit spread</td>
<td>term structure</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------</td>
<td>--------------</td>
<td>---------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Risk, contemp</td>
<td>$\sigma$</td>
<td>13.94</td>
<td>5.07</td>
<td>20.58</td>
<td>0.97</td>
</tr>
<tr>
<td>Signals on risk</td>
<td>$\sigma_{signal}$</td>
<td>68.29</td>
<td>44.23</td>
<td>75.90</td>
<td>6.79</td>
</tr>
<tr>
<td>Risk and signals</td>
<td>$\sigma$ and $\sigma_{signal}$</td>
<td>82.22</td>
<td>49.30</td>
<td>96.48</td>
<td>7.76</td>
</tr>
</tbody>
</table>

Signal matters!

all shocks               | 100.00      | 100.00       | 100.00        | 100.00         |
Importance of Risk Signals

News Specification on Risk and Marginal Likelihood (EA data)

$$\hat{\sigma}_t = \rho_1 \hat{\sigma}_{t-1} + \xi_{t-0}^0 + \xi_{t-1}^1 + \xi_{t-2}^2 + \ldots + \xi_{t-p}^p$$

<table>
<thead>
<tr>
<th>$p$</th>
<th>log, marginal likelihood</th>
<th>odds ($=\exp($difference in log likelihood from baseline$))</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 (baseline)</td>
<td>4397.487</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>4394.025</td>
<td>31</td>
</tr>
<tr>
<td>1</td>
<td>4325.584</td>
<td>$\infty$</td>
</tr>
</tbody>
</table>
Why is Risk Shock so Important?

• According to the model, external finance premium is primarily risk shock.

• To look for evidence that risk might be important, look at dynamics of external finance premium and gdp.

• External finance premium is a negative leading indicator
Figure 1: Correlation(finance premium (t), output (t-j)), HP filtered data, 95% confidence interval

Notes: Premium is measured by the difference between the yield on the lowest rated corporate bonds (Baa) and the highest rated corporate bonds (Aaa). Bond rate data obtained from St. Louis Fed website. GDP data obtained from Balke and Gordon (1986). Filtered output data are scaled so that their standard deviation coincide with that of the premium data.
Why is Risk Shock so Important?: A second reason

- Our data set includes the stock market
  
  - Output, stock market, investment all procyclical (surge together in late 1990s)
  
  - This is predicted by risk shock.
Shock to Distribution of Idiosyncratic Shock Across Entrepreneurs

Standard deviation of idiosyncratic shock increased 10% from 0.83 to 0.91
Response to Shock in Cross-entrepreneur Distribution

Output

Investment

Consumption

Real Net Worth

Premium (Annual Rate)

Total Loans (Real)
Impact of Financial Frictions on Propagation

• Effects of monetary shocks on gdp amplified by BGG financial frictions because $P$ and $Y$ go in same direction.

• Effects of technology shocks on gdp mitigated by BGG financial frictions because $P$ and $Y$ go in opposite directions.
Baseline model with no Fisher Effect

Output Response to 40 Basis Point Jump in Interest Rate

Output Response to a Neutral Technology Shock

Baseline model

Blue line: baseline model with no financial frictions
Out of Sample RMSEs

• There is not a loss of forecasting power with the additional complications of the model.

• The model does well on everything, except the risk premium.
Figure 6.a. EA, RMSE: Confidence band represents 2 std and is centred around BVAR.
Models with Financial Frictions Can be Used to Address Important Policy Questions

- When there is an increase in risk spreads, how should monetary policy respond?
- How should monetary policy react to credit variables and the stock market?
- Does monetary policy cause excess asset price volatility?
  - Taylor: deviations from Taylor rule may cause asset price volatility
  - Christiano-Ilut-Motto-Rostagno: Taylor rule may cause asset price volatility
How Should Policy Respond to the Risk Spread?

• Taylor’s recommendation:

\[ R_t = \alpha \pi_t^e + \beta y_t - \gamma (\text{Risky rate}_t - \text{Risk free rate}_t) \]

\(\gamma = 1\)

• Evaluate this proposal by comparing performance of economy with \(\gamma = 1\) and \(\gamma = 0\) against Ramsey-optimal benchmark.
Get a recession, just like in earlier graph.
Taylor's suggestion creates a boom. Is it too much?
Taylor’s suggestion overstimulates
Conclusion of Empirical Analysis with Financial Frictions

• Incorporating financial frictions changes inference about the sources of shocks and of propagation
  
  – risk shock.
  – Fisher debt deflation

• Opens a range of interesting questions that can be addressed