Risk Shocks

Lawrence Christiano (Northwestern University), Roberto Motto (ECB) and Massimo Rostagno (ECB)

*The Causes and Macroeconomic Consequences of Uncertainty*
Dallas Fed, October 3, 2013
Finding

• Countercyclical fluctuations in the cross-sectional variance of a type of technology shock, when inserted into a widely-used business cycle model, can account for a substantial portion of economic fluctuations.


– Complements theory findings of Bloom (2009) and Bloom, Floetotto and Jaimovich (2009) which describe another way that increased cross-sectional dispersion can generate business cycles.

Also:


• Model used in analysis:

– A DSGE model, as in Christiano-Eichenbaum-Evans or Smets-Wouters.

– Financial frictions along the line suggested by BGG.
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Outline

• Rough description of the model.

• Estimation results.

• Explanation of the basic results.
Standard Model

- Firms
- Labor market
- Household

$L$
Standard Model

Firms

Labor market

household

Market for Physical Capital

$L$ to $K$
Standard Model

- Firms
- Labor market
- Household
- Market for Physical Capital

Relations:
- \( L \) from Labor market to Firms
- \( C \) from Firms to Household
- \( I \) from Firms to Market for Physical Capital
- \( K \) from Market for Physical Capital to Firms
Standard Model

Firms

Labor market

Market for Physical Capital

household

\[ K_{t+1} = (1 - \delta)K_t + G(\zeta_{t,t}, I_t, I_{t-1}) \]

Marginal efficiency of investment shock
Standard Model with BGG

Firms

Labor market

$L$

household
Standard Model with BGG

- Firms
- Labor market
- Household
- Entrepreneurs

\[ L \rightarrow \gamma K \sim F, \alpha_t \rightarrow \]
Standard Model with BGG

\[ K \rightarrow \omega K, \ \omega \sim F(\cdot, \sigma_t) \]
Standard Model with BGG

Examples:
1. Large proportion of firm start-ups end in failure

$K \rightarrow \omega K$, $\omega \sim F(\cdot, \sigma_t)$
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Standard Model with BGG

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1. Large proportion of firm start-ups end in failure
2. Even famously successful entrepreneurs (Gates, Jobs) had failures (Traf-O-Data, NeXT computer)
3. Wars over standards (e.g., Betamax versus VHS).

\[ K \rightarrow \omega K, \quad \omega \sim F(\cdot, \sigma_t) \]
Standard Model with BGG

Firms

Labor market

household

Entrepreneurs

$K \rightarrow \omega K, \omega \sim F(\cdot, \sigma_t)$

Observed by entrepreneur, but supplier of funds must pay monitoring cost to see it.
Standard Model with BGG

Firms

Labor market

household

Entrepreneurs

Risk shock

\[ K \rightarrow \omega K, \ \omega \sim F(\cdot, \sigma_t) \]
Standard Model with BGG

Firms

Labor market

Capital Producers

Entrepreneurs

Entrepreneurs sell their \( \omega K \) to capital producers

\[ K_{t+1} = (1 - \delta)K_t + G(\xi_{t,t}, I_t, I_{t-1}) \]

\( K \rightarrow \omega K, \omega \sim F(\cdot, \sigma_t) \)
Entrepreneurial net worth now established….

\[ K \rightarrow \omega K, \ \omega \sim F(\cdot, \sigma_t) \]

\[ \text{Entrepreneurial net worth now established} \ldots \]

\[ = \text{value of capital} + \text{earnings from capital} \]

\[- \text{repayment of bank loans} \]
Standard Model with BGG

$K \rightarrow \omega K, \ \omega \sim F(\cdot, \sigma_t)$

- Firms
- Labor market
- Capital Producers
- Entrepreneurs
- Entrepreneur receives standard debt contract.

household \rightarrow banks
Standard Model with BGG

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Entrepreneur receives standard debt contract.
Economic Impact of Risk Shock
Economic Impact of Risk Shock

lognormal distribution:
20 percent jump in standard deviation

idiosyncratic shock

\[ \sigma \]

\[ \cdot \sigma \ast 1.2 \]
Economic Impact of Risk Shock

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20 percent jump in standard deviation

Larger number of entrepreneurs in left tail problem for lender
Economic Impact of Risk Shock

lognormal distribution: 20 percent jump in standard deviation

Larger number of entrepreneurs in left tail problem for lender

Interest rate on loans to entrepreneur increases
Economic Impact of Risk Shock

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Larger number of entrepreneurs in left tail problem for lender
Interest rate on loans to entrepreneur increases
Entrepreneur borrows less
Economic Impact of Risk Shock

lognormal distribution:
20 percent jump in standard deviation

Larger number of entrepreneurs in left tail problem for lender
Interest rate on loans to entrepreneur increases
Entrepreneur borrows less
Entrepreneur buys less capital, investment drops, economy tanks
Risk Shocks

• We assume risk has a first order autoregressive representation:

\[ \sigma_t = \rho \sigma_{t-1} + u_t \]

iid statistical innovation
Risk Shocks

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• Standard information assumption:
  – Agents become aware of \( u_t \) when it’s realized.
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\[ u_t = \xi_t^0 \xi_{t}^{1} + \xi_{t-1} + \xi_{t-2} + \ldots + \xi_{t-8} \]

\( \xi_t \) unanticipated component
\( \xi_{t-1}, \xi_{t-2}, \ldots, \xi_{t-8} \) anticipated component of \( u_t \) ‘news’, or ‘signals’
News on Risk Shocks Versus News on Other Shocks

DSGE Baseline

Marginal likelihood

4493.85
### News on Risk Shocks Versus News on Other Shocks

<table>
<thead>
<tr>
<th>Model</th>
<th>Marginal Likelihood</th>
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<tbody>
<tr>
<td>DSGE Baseline</td>
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<td>DSGE with Signals on Monetary Policy and No Signals on Risk Shock ($\sigma$)</td>
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## News on Risk Shocks Versus News on Other Shocks

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<td>DSGE with Signals on Technology Shocks and No Signals on Risk Shock ($\sigma$)</td>
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Monetary Policy

• Nominal rate of interest function of:
  – Anticipated level of inflation.
  – Slowly moving inflation target.
  – Deviation of output growth from ss path.
  – Monetary policy shock.
12 Shocks

- Trend stationary and unit root technology shock.
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- Marginal Efficiency of investment shock (perturbs capital accumulation equation)
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\bar{K}_{t+1} = (1 - \delta)\bar{K}_t + G(\zeta_{i,t}, I_t, I_{t-1})
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- Monetary policy shock.

- Equity shock.
12 Shocks

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- Monetary policy shock.

- Equity shock.

- Risk shock.
12 Shocks

- Trend stationary and unit root technology shock.
- Marginal Efficiency of investment shock (perturbs capital accumulation equation)

\[ \bar{K}_{t+1} = (1 - \delta)\bar{K}_t + G(\zeta_{i,t}, I_t, I_{t-1}) \]

- Monetary policy shock.
- Equity shock.
- Risk shock.
- 6 other shocks.
Inference

• Use standard macro data: consumption, investment, employment, inflation, GDP, price of investment goods, wages, Federal Funds Rate.
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• Also some financial variables: BAA - 10 yr Tbond spreads, value of DOW, credit to nonfinancial business, 10 yr Tbond – Funds rate.
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• Also some financial variables: BAA - 10 yr Tbond spreads, value of DOW, credit to nonfinancial business, 10 yr Tbond – Funds rate.

• Data: 1985Q1-2010Q2
Results

• Risk shock most important shock for business cycles.
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• Quantitative measures of importance.
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• *Why* are they important?
Results

• Risk shock most important shock for business cycles.

• Quantitative measures of importance.

• Why are they important?

• Some Direct Evidence on Risk Shocks.
Figure 5: The Role of the Risk Shock in Selected Variables

a. GDP growth (year-on-year %)

Grey, solid line: data when all shocks are fed to model.
Figure 5: The Role of the Risk Shock in Selected Variables

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a. GDP growth (year-on-year %)

b. Equity (log-level)

c. Credit growth (year-on-year %)

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Figure 5: The Role of the Risk Shock in Selected Variables

a. GDP growth \((\text{year-on-year} \%)\)
b. Equity \((\log\text{-level})\)
c. Credit growth \((\text{year-on-year} \%)\)
d. Credit spread \((\text{p.p. per annum})\)

Grey, solid line: data when all shocks are fed to model.

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Percent Variance in Business Cycle Frequencies Accounted for by Risk Shock

<table>
<thead>
<tr>
<th>variable</th>
<th>Risk, $\sigma_t$</th>
</tr>
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<tbody>
<tr>
<td>GDP</td>
<td>62</td>
</tr>
<tr>
<td>Investment</td>
<td>73</td>
</tr>
<tr>
<td>Consumption</td>
<td>16</td>
</tr>
<tr>
<td>Credit</td>
<td>64</td>
</tr>
<tr>
<td>Premium ($Z - R$)</td>
<td>95</td>
</tr>
<tr>
<td>Equity</td>
<td>69</td>
</tr>
<tr>
<td>$R^{10 \text{ year}} - R^{1 \text{ quarter}}$</td>
<td>56</td>
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Note: ‘business cycle frequencies means’ Hodrick-Prescott filtered data.
Why Risk Shock is so Important

• In the model:

  – jump in risk, $\sigma_t$, generates a response that resembles a recession
Figure 3: Dynamic Responses to Unanticipated and Anticipated Components of Risk Shock
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A: interest rate spread (Annual Basis Points)

B: credit

C: investment

D: output

E: net worth

F: consumption

G: inflation (APR)

response to unanticipated risk shock

response to anticipated risk shock
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(response to unanticipated risk shock, \( \sigma_t \))
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- **G**: Inflation (APR)
- **H**: Risk, $\sigma_t$
Figure 3: Dynamic Responses to Unanticipated and Anticipated Components of Risk Shock

Looks like a business cycle
What Shock Does the Risk Shock Displace, and why?

• The risk shock mainly crowds out the marginal efficiency of investment.
Why does Risk Crowd out Marginal Efficiency of Investment?

Demand shifters:
- risk shock, \( \sigma_t \);
- wealth shock, \( \lambda_t \);

Price of capital

Quantity of capital
Why does Risk Crowd out Marginal Efficiency of Investment?

Price of capital

Demand shifters: risk shock, $\sigma_t$;

Supply shifter: marginal efficiency of investment, $\zeta_{i,t}$

Quantity of capital
• Marginal efficiency of investment shock can account well for the surge in investment and output in the 1990s, as long as the stock market is not included in the analysis.
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• When the stock market is included, then explanatory power shifts to financial market shocks.
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• When the stock market is included, then explanatory power shifts to financial market shocks.

• When we drop ‘financial data’ – slope of term structure, interest rate spread, stock market, credit growth:
  – Hard to differentiate risk shock view from marginal efficiency of investment view.
Out of Sample Checks

• Evaluated model by looking at implications for data not in the estimation sample:
Out of Sample Checks

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  – Measure of loan delinquency rates.
Out of Sample Checks

• Evaluated model by looking at implications for data not in the estimation sample:
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  – Out-of-sample forecasts.
Out of Sample Checks

• Evaluated model by looking at implications for data not in the estimation sample:

  – Measure of loan delinquency rates.
  – Out-of-sample forecasts.
  – Firm-level stock return data in CRSP.
Cross sectional standard deviation of quarterly rate of return on non-financial firm equity, CRSP data and model

- **data (left axis)**
- **model (right axis)**

std deviation, quarterly return

std deviation, quarterly return
Cross sectional standard deviation of quarterly rate of return on non-financial firm equity, CRSP data and model

- Blue line: data (left axis)
- Red line: model (right axis)
Conclusion

• US Business Cycle data ‘looks’ as though they are driven by fluctuations in business uncertainty....
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• US Business Cycle data ‘looks’ as though they are driven by fluctuations in business uncertainty….risk shocks.