Financial Frictions for Macro-Finance

Arvind Krishnamurthy, Northwestern University and NBER

May 2014
1 Why are we interested in financial frictions? Why study the financial intermediary sector?

2 Intellectual history: Amplification and persistence (Bernanke-Gertler, Kiyotaki-Moore)

3 Recent work: He-Krishnamurthy, Brunnermeier-Sannikov, Adrian-Boyarchenko, Maggiori, DiTella, Gertler-Kiyotaki, Rampini-Viswanathan

4 Open questions
Financial Sector Losses

- Subprime losses $\approx$ $500$ billion
- 2% fall in stock market
Financial Sector Losses

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- Wealth losses due to real estate decline = $7$ trillion
- Dot-com bust 2000 to 2002 = $8$ trillion loss of wealth
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Who bears the losses is critical.

- Not representative agent. Distribution/heterogeneity matters.
- *How do shocks affect the distribution of wealth across the economy?*
Aggregate Shocks and Risk Premia (Muir, 2014)

Panel A: Changes in Risk Premia

Panel B: Consumption State Variables

Panel C: Intermediary State Variables
Financial Friction limits Flow of Funds

PRODUCTIVE SECTOR (FIRMS) → PAYOUTS → SAVINGS SECTOR (HOUSEHOLDS) → FINANCING → PRODUCTIVE SECTOR (FIRMS)
Wealth Distribution

PRODUCTIVE SECTOR (FIRMS) \( W^P \)

SAVINGS SECTOR (HOUSEHOLDS) \( W^S \)

PAYOUTS

FINANCING
TFP shocks affect wealth distribution, \( (W_t^P, W_t^S) \)

- Positive TFP shock increases profits \( \Pi_t \), \( W_{t+1}^P \)
- Investment at \( t + 1 \) closer to first best as wealth shifts towards \( W_{t+1}^P \)
- Output and \( \Pi_{t+1} \) at \( t + 1 \) rise
TFP shocks affect wealth distribution, \((W^P_t, W^S_t)\)

\[
W^P_{t+1} = W^P_t + \Pi_t
\]
\[
W^S_{t+1} = W^S_t (1 + r_t)
\]

Positive TFP shock increases profits \(\Pi_t\), \(W^P_{t+1}\)
Investment at \(t + 1\) closer to first best as wealth shifts towards \(W^P_{t+1}\)
Output and \(\Pi_{t+1}\) at \(t + 1\) rise

“Financial Accelerator”: Profits \(\Pi_{t+1}\) rise, increase wealth \(W^P_{t+1}\), profits \(\Pi_{t+2}\)
TFP shocks affect wealth distribution, \((W^p_t, W^s_t)\)

\[
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W^{s}_{t+1} &= W^{s}_t (1 + r_t)
\end{align*}
\]

- Positive TFP shock increases profits \(\Pi_t, W^{p}_{t+1}\)
- Investment at \(t + 1\) closer to first best as wealth shifts towards \(W^{p}_{t+1}\)
- Output and \(\Pi_{t+1}\) at \(t + 1\) rise
- **"Financial Accelerator"**: Profits \(\Pi_{t+1}\) rise, increase wealth \(W^{p}_{t+1}\), profits \(\Pi_{t+2}\)...
- Credit boom
- Slow recovery, long slump (US 2009-, Japan lost decade)
$W_t^P$ is a portfolio that includes long-lived assets (physical capital)

Value of long-lived assets:

$$V_t = \sum_{s=t}^{\infty} R^{s-t} \Pi_s$$
Amplification: Kiyotaki-Moore (1997)

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  \[
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- **Dynamic amplification**: time $t$ TFP shock causes persistent changes in $\Pi_s$, implying large valuation effect at $t$
- TFP shock amplified as a shock to $W_t^P$ through change in asset values
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- TFP shock amplified as a shock to $W_t^P$ through change in asset values
- “Pebble that started the avalanche": small shock/large effect
- Real estate and 2007-2009 financial crisis
Intermediaries Matter


Intermediary-Firm Coalition

![Diagram showing connections between productive sector (firms), intermediary sector (banks), and savings sector (households) with no frictions.](image-url)
Kiyotaki-Moore: Volatility due to cash flow variation

\[ V_t = \sum_{s=t}^{\infty} R^{s-t} \Pi_s \]

Finance perspective: \( R \) variation more important than \( \Pi \) variation in asset pricing.
Kiyotaki-Moore: Volatility due to cash flow variation

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Finance perspective: \( R \) variation more important than \( \Pi \) variation in asset pricing.

Wealth distribution and asset prices:

\( W_t^B \) particularly important for “intermediated” assets
Figure 4. The corporate-bond CDS basis, the difference between the CDS rate and the associated par bond yield spread, is theoretically near zero in frictionless markets. As shown, the average CDS basis across portfolios of U.S. investment-grade bonds and high-yield bonds widened dramatically during the financial crisis and then narrowed as the crisis subsided. The underlying data, kindly provided to the author by Mark Mitchell and Todd Pulvino, cover an average of 484 investment-grade issuers per week and 208 high-yield issuers per week. For additional details, see Mitchell and Pulvino (2010).

From: Duffie, AFA Presidential Address 2010
Fire-sales: CIP Deviations

Panel A: EURO basis, January 2007 - January 2012

Figure 3 from Ivashina, Scharfstein and Stein (2012)
Adrian, Etula, and Muir (JF 2012), Broker-Dealer Leverage to measure an intermediary pricing kernel (rough proxy for $W_t^B$)

$$\text{B/D leverage} = \frac{\text{Assets of B/D sector}}{\text{Assets} - \text{Liabilities}}$$

From Federal Reserve Flow of Funds: Book values for many things, slow updating (can surely do better!)
Intermediary Pricing Kernel

Black = FF25, Red = 10momentum, Blue = 6 Bonds
Risk Premia in Stochastic Models

He-Krishnamurthy, Brunnermeier-Sannikov, Adrian-Boyarchenko, Maggiori, DiTella

Bernanke-Gertler, Kiyotaki-Moore linearize around deterministic steady state; agents are locally risk-neutral

- No possibility for $R$ variation
- ... leaves out potentially powerful amplifier through changes in risk-premia
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2. Linearization means amplification is constant
   - Conditional amplification: Lehman shock versus Bear shock
   - Amplification a non-linear function of underlying state variable
   - Transition from "normal" to "crisis"
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Linearization means amplification is constant

- Conditional amplification: Lehman shock versus Bear shock
- Amplification a non-linear function of underlying state variable
- Transition from “normal” to “crisis”
He-Krishnamurthy (2013)

- Two classes of agents: households and bankers
  - Households:
    \[
    \mathbb{E} \left[ \int_0^\infty e^{-\rho t} \frac{1}{1-\gamma} C_t^{1-\gamma} dt \right], \quad C_t = (c_t^y)^{1-\phi} \left( c_t^h \right)^{\phi}
    \]

- Two types of capital: productive capital $K_t$ and housing capital $H$.
  - Fixed supply of housing $H \equiv 1$
  - Price of capital $q_t$ and price of housing $P_t$ determined in equilibrium
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- Production $Y = AK_t$, with $A$ being constant

- Fundamental shocks: stochastic capital quality shock $dZ_t$. TFP shocks
  \[ \frac{dK_t}{K_t} = i_t dt - \delta dt + \sigma dZ_t \]
He-Krishnamurthy (2013)

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  \[ \frac{dK_t}{K_t} = i_t dt - \delta dt + \sigma dZ_t \]

- Investment/Capital $i_t$, quadratic adjustment cost
  \[ \Phi(i_t, K_t) = i_t K_t + \frac{\kappa}{2} (i_t - \delta)^2 K_t \]
  \[ \max_{i_t} q_t i_t K_t - \Phi(i_t, K_t) \Rightarrow i_t = \delta + \frac{q_t - 1}{\kappa} \]
Aggregate Balance Sheet

Loans to Capital Producers $i_t$

Intermediary Sector

Capital $q_t K_t$

Equity $E_t$

Housing $P_t H$

Debt $W_t - E_t$

Household Sector

Financial Wealth

$W_t = q_t K_t + P_t H$
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$W_t = q_tK_t + P_tH$

$(1 - \lambda)W_t$

$\lambda W_t = "Liquid balances"$

benchmark capital structure
Equity Matters

Loans to Capital Producers $i_t$

Intermediary Sector

Capital $q_t K_t$

Equity $E_t$

Housing $P_t H$

Debt $W_t - E_t$

Separation of ownership and control

Banker maximizes $E[ROE] - \frac{m}{2} Var[ROE]$

Household Sector

Financial Wealth

$W_t = q_t K_t + P_t H$

$(1 - \lambda) W_t$

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benchmark capital structure
Equity Dynamics in GE

Loans to Capital Producers $i_t$

Intermediary Sector

Capital $q_tK_t$

Equity $E_t$

-10% × Lev

Debt $W_t - E_t$

Banker maximizes $E[ROE] - \frac{m}{2} \text{Var}[ROE]$

Housing $P_tH$

-10%

Household Sector

Financial Wealth

$W_t = q_tK_t + P_tH$

(1 − $\lambda$) $W_t$

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Equity Constraint

Loans to Capital Producers $i_t$

Intermediary Sector

Capital $q_t K_t$

Equity $E_t$

Constraint: $E_t \leq \mathcal{E}_t$

Housing $P_t H$

Debt $W_t - E_t$

Banker maximizes $E[ROE] - \frac{m}{2} \text{Var}[ROE]$

Aggregate intermediary equity constraint $\mathcal{E}_t$

Financial Wealth

$W_t = q_t K_t + P_t H$

(1 - $\lambda$) $W_t$

$\lambda W_t = "Liquid balances"$

Household Sector
Equity constraint: $\epsilon_t$

- Bank can raise equity upto $\epsilon_t$ at zero cost
- Cost of raising equity more than $\epsilon_t$ is infinite.
- $\epsilon_t$ linked to intermediary performance (constant $m$)

\[
\frac{d\epsilon_t}{\epsilon_t} = m \tilde{R}_t.
\]
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$$\frac{d\epsilon_t}{\epsilon_t} = md\tilde{R}_t.$$

- Poor returns reduce “reputation”: Berk-Green, 04; flow-performance relationship, Warther 95; Chevalier-Ellison, 97
- Or, $\epsilon_t$ as banker’s “net worth” fluctuating with past returns
  - Kiyotaki-Moore 97, He-Krishnamurthy 12, Brunnermeier-Sannikov 12
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Aggregate dynamics of $\mathcal{E}_t = \int \epsilon_t$

$$\frac{d\mathcal{E}_t}{\mathcal{E}_t} = m d\tilde{R}_t - \eta dt + d\psi_t$$

- Exogenous death rate $\eta$. Endogenous entry $d\psi_t > 0$ of new bankers in extreme bad states
Equity Capital Constraint

- Representative household with $W_t$, split between bonds (at least) $\lambda W_t$ and equity (at most) $(1 - \lambda) W_t$

- Benchmark capital structure: $\lambda W_t$ of Debt, $(1 - \lambda) W_t$ of Equity
  - if there is no capital constraint ($\mathcal{E}_t$ is infinite)...
Equity Capital Constraint

- Representative household with $W_t$, split between bonds (at least) $\lambda W_t$ and equity (at most) $(1 - \lambda) W_t$
- Benchmark capital structure: $\lambda W_t$ of Debt, $(1 - \lambda) W_t$ of Equity
  - if there is no capital constraint ($E_t$ is infinite)...
- Intermediary equity capital:

$$E_t = \min [E_t, (1 - \lambda) W_t]$$

- Suppose a $-10\%$ shock to real estate and price of capital:
- $W_t \downarrow 10\%$ (Household wealth = aggregate wealth)
- Reputation: $\frac{dE_t}{E_t} = md\tilde{R}_t + \ldots$ Two forces make $E_t \downarrow$ more than $10\%$:
  1. Return on equity $= d\tilde{R}_t < -10\%$: equity is levered claim on assets
  2. $m > 1$ in our calibration
### Single Bank/Banker Choice of Portfolio and Leverage

<table>
<thead>
<tr>
<th>Capital $q_t k_t$</th>
<th>$equity_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing $P_t h_t$</td>
<td>$debt_t$</td>
</tr>
</tbody>
</table>

Portfolio share in capital: $\alpha^k_t = \frac{q_t k_t}{equity_t}$

Portfolio share in housing: $\alpha^h_t = \frac{P_t h_t}{equity_t}$

Borrowing (no constraint): $debt_t = q_t k_t + P_t h_t - equity_t = (\alpha^k_t + \alpha^h_t - 1) equity_t$
Bank Choice of Portfolio and Leverage

| Capital | $q_t k_t$ | equity$_t$ |
| Housing | $P_t h_t$ | debt$_t$ |

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Return on bank equity ROE: $d\tilde{R}_t = \alpha^k_t dR^k_t + \alpha^h_t dR^h_t - (\alpha^k_t + \alpha^h_t - 1) r_t dt$

Banker (log preference) solves: $\max_{\alpha^k_t, \alpha^h_t} \mathbb{E}_t [d\tilde{R}_t - r_t dt] - \frac{m}{2} \text{Var}_t [d\tilde{R}_t]$
Bank Choice of Portfolio and Leverage

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<th>Housing</th>
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<td>$q_t k_t$</td>
<td>$P_t h_t$</td>
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**Properties**
- $(k, h)$ scales with $equity$
- $(k, h)$ increasing in $\mathbb{E}_t[d\tilde{R}_t - r_t dt]$
- $(k, h)$ decreasing in $\text{Var}_t[d\tilde{R}_t]$
**General Equilibrium**

**Intermediary Sector**

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<tr>
<th>Capital $q_tK_t$</th>
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<td>Debt $W_t - E_t$</td>
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<th>Household Sector</th>
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<th>Financial Wealth</th>
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\[ W_t = q_tK_t + P_tH \]

**Portfolio share in capital:**
\[ \alpha^k_t = \frac{q_tK_t}{E_t} = \frac{q_tK_t}{\min[E_t, (1-\lambda)W_t]} \]

**Portfolio share in housing:**
\[ \alpha^h_t = \frac{P_tH}{E_t} = \frac{P_tH}{\min[E_t, (1-\lambda)W_t]} \]

- Given state $(K_t, E_t)$, the equilibrium portfolio shares are pinned down by GE.
- But portfolio shares must also be optimally chosen by banks, pinning down prices.

\[ \max_{\alpha^k_t, \alpha^h_t} \mathbb{E}_t[d\tilde{R}_t - r_t dt] - \frac{m}{2} \text{Var}_t[d\tilde{R}_t] \]

- Asset prices affect real side through investment $(q_t)$.
## General Equilibrium (2)

### Intermediary Sector

<table>
<thead>
<tr>
<th>Capital $q_tK_t$</th>
<th>Equity $E_t$</th>
<th>Constraint: $E_t \leq \varepsilon_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing $P_tH$</td>
<td>Debt $W_t - E_t$</td>
<td>Financial Wealth $W_t = q_tK_t + P_tH$</td>
</tr>
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- **Portfolio share in capital:** $\alpha^k_t = \frac{q_tK_t}{E_t} = \frac{q_tK_t}{\min[E_t,(1-\lambda)W_t]}$
- **Portfolio share in housing:** $\alpha^k_t = \frac{P_tH}{E_t} = \frac{P_tH}{\min[E_t,(1-\lambda)W_t]}$

- Prices (returns) have to adjust for optimality:
  - $\mathbb{E}_t[dR^h_t - r_tdt], \mathbb{E}_t[dR^k_t - r_tdt] \Rightarrow \text{equations for } \mathbb{E}_t[dP_t], \mathbb{E}_t[dq_t]$

- Rewrite to get Partial Differential Equations for $P(K, \varepsilon)$ and $q(K, \varepsilon)$

- Scale invariance: Define $e = \varepsilon/K$; then $P = Kp(e)$ and $q(e)$, PDEs become ODEs
### Calibration: Baseline Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Choice</th>
<th>Targets (Unconditional)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Intermediation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m$</td>
<td>Performance sensitivity</td>
<td>2</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>Debt ratio</td>
<td>0.67</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Banker exit rate</td>
<td>13%</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Entry trigger</td>
<td>6.5</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Entry cost</td>
<td>2.43</td>
</tr>
<tr>
<td><strong>Panel B: Technology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Capital quality shock</td>
<td>3%</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Depreciation rate</td>
<td>10%</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Adjustment cost</td>
<td>3</td>
</tr>
<tr>
<td>$A$</td>
<td>Productivity</td>
<td>0.133</td>
</tr>
<tr>
<td><strong>Panel C: Others</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho$</td>
<td>Time discount rate</td>
<td>2%</td>
</tr>
<tr>
<td>$\xi$</td>
<td>1/EIS</td>
<td>0.15</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Housing share</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Results(1): State variable is $e_t = \mathcal{E}_t / K_t$

- Sharpe ratio
- Interest rate
- $q(e)$, capital price
- Investment $I/K$

- Capital constraint binds for $e < 0.435$
Capital constraint binds for $e < 0.435$

Without the possibility of the capital constraint, all of these lines would be flat. Model dynamics would be i.i.d., with vol=3%. Endogenously time-varying “uncertainty.”
State-dependent Impulse Response: -1% Shock \( (\sigma dZ_t) \)
Steady State Distribution

steady state distribution

scaled intermediary reputation e
Nonlinearities in Model and Data

Model:
- Distress states = worst 33% of realizations of $e$ ($e < 1.27$)
- Compute conditional variances, covariances of intermediary equity growth with other key variables

Data:
- Distress states = worst 33% of realizations of (risk premium in) credit spread
  - We use Gilchrist-Zakrajsek (2011) Excess Bond Premium, which we convert to a Sharpe ratio
  - Excess Bond Premium: risk premium of corporate bonds, presumably reflects distress of financial sector
  - Similar results if using NBER recessions
- Compute conditional variances, covariances of intermediary equity growth with other key variables
EBS time series
Matching State-Dependent Covariances

<table>
<thead>
<tr>
<th></th>
<th>Distress</th>
<th></th>
<th>Non Distress</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data</td>
<td>Baseline</td>
<td>Data</td>
<td>Baseline</td>
</tr>
<tr>
<td>vol (Eq)</td>
<td>31.48%</td>
<td>34.45%</td>
<td>17.54%</td>
<td>5.4</td>
</tr>
<tr>
<td>vol (I)</td>
<td>8.05%</td>
<td>5.30</td>
<td>6.61</td>
<td>4.2</td>
</tr>
<tr>
<td>vol (C)</td>
<td>1.71%</td>
<td>3.54</td>
<td>1.28</td>
<td>1.19</td>
</tr>
<tr>
<td>vol (EB)</td>
<td>60.14%</td>
<td>74.20</td>
<td>12.72</td>
<td>7.97</td>
</tr>
<tr>
<td>cov (Eq, I)</td>
<td>1.31%</td>
<td>1.05</td>
<td>0.07</td>
<td>0.23</td>
</tr>
<tr>
<td>cov (Eq, C)</td>
<td>0.25%</td>
<td>-0.96</td>
<td>0.03</td>
<td>-0.05</td>
</tr>
<tr>
<td>cov (Eq, LP)</td>
<td>4.06%</td>
<td>5.87</td>
<td>0.12</td>
<td>0.5</td>
</tr>
<tr>
<td>cov (Eq, EB)</td>
<td>-6.81%</td>
<td>-14.95</td>
<td>-0.14</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

- Note: without the capital constraint, all volatilities would be 3%, and have no state dependence.
- What we do badly on: Output vol is locally $\sigma$ because $Y_t = AK_t$. Financial friction only affects split between I and C.
Matching the 2007-2009 Crisis
Based on EBS classification, economy crossed the 33% boundary \((e = 1.27)\) between 2007Q2 and 2007Q3. Assume \(e = 1.27\) in 2007Q2.

Then choose \((Z_{t+1} - Z_t)\) shocks to match realized intermediary equity series.

<table>
<thead>
<tr>
<th></th>
<th>07QIII</th>
<th>07QIV</th>
<th>08QI</th>
<th>08QII</th>
<th>08QIII</th>
<th>08QIV</th>
<th>09QI</th>
<th>09QII</th>
<th>09QIII</th>
<th>09QIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread</td>
<td>-2.5%</td>
<td>-4.2</td>
<td>-1.1</td>
<td>-1.1</td>
<td>-0.7</td>
<td>-1.6</td>
<td>-1.8</td>
<td>-1.8</td>
<td>-0.9</td>
<td>-0.9</td>
</tr>
</tbody>
</table>

- Total -15.5%. Capital constraint binds after 07Q4—systemic risk state
- In the model (data), land price falls by 50% (55%)
- In the model (data), investment falls by 23% (25%)
Summary

- Capital constraint drives risk premia and aggregate investment
- Effects are non-linear
- Non-linearity can match important data moments
Capital constraint drives risk premia and aggregate investment
Effects are non-linear
Non-linearity can match important data moments

Open questions...
No passthrough to real sector (red dashed line).

1987 Stock Market Crash. 2005 GM/Ford downgrade and CDS.
Financial and Real Shocks

- Financial shocks have real effects sometimes, but not all the time.
- Is it that the corporate sector is able to bypass the intermediary sector problems? ("triple-decker model")
Financial shocks have real effects sometimes, but not all the time.

1987, 1998: Is it adequate policy response?

Is it that the corporate sector is able to bypass the intermediary sector problems? ("triple-decker model")

Note that models are clear on when real shocks have financial amplifier effects: It depends on intermediary capital state variable.
<table>
<thead>
<tr>
<th>Outcome variable</th>
<th>Mean</th>
<th>Median</th>
<th>Std Dev</th>
<th>10th</th>
<th>90th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (GDP)</td>
<td>5.9</td>
<td>4.0</td>
<td>5.6</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Spread Duration</td>
<td>3.1</td>
<td>1.0</td>
<td>3.6</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>

- Financial variables settle back more quickly than real variables.
- Two state variables...
CDS and Build-up

- BofA 5yr CDS
- LEH 5yr CDS
Forecasting Crises (from Krishnamurthy-Muir)

\[ \text{depth}_{i,t} = \alpha + b \times \text{spread}_{i,t} + \varepsilon_{i,t} \]

<table>
<thead>
<tr>
<th></th>
<th>( b )</th>
<th>se(b)</th>
<th>( \sigma (b \times \text{spread}_{i,t}) )</th>
<th>Adj( R^2 )</th>
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<tbody>
<tr>
<td><strong>ST Dates</strong></td>
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- \( \text{depth}_{i,t} \) = Peak to trough decline in GDP
- \( \text{spread}_{i,t} \) = corporate bond spread once crisis starts
- ST=Schularick-Taylor; RR = Reinhart-Rogoff
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\[ \text{spread}_{i,t} = 0.9 \times \text{spread}_{i,t-1} + u_t \]

All the action is in \( u_t \). What is the shock?
Conclusion

- Financial and real side are closely tied together in the data, especially in crises.
- Models tie them together through shifting distribution of wealth.
- Recent progress in stochastic models with variation in risk premia, asset prices, and macro outcomes.
- Many open questions: financial and real shocks, multiple state variables, policy responses, shocks that cause crises.
Financial and real side are closely tied together in the data, especially in crises.
Models tie them together through shifting distribution of wealth.
Recent progress in stochastic models with variation in risk premia, asset prices, and macro outcomes.
Many open questions: financial and real shocks, multiple state variables, policy responses, shocks that cause crises.
Monetary models: monetary policy shocks affects risk premia (Hanson-Stein 2013, Nakamura-Steinsson 2013, Drechsler-Savov-Schnabl, 2014)