Financial Frictions for Macro-Finance

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Outline

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

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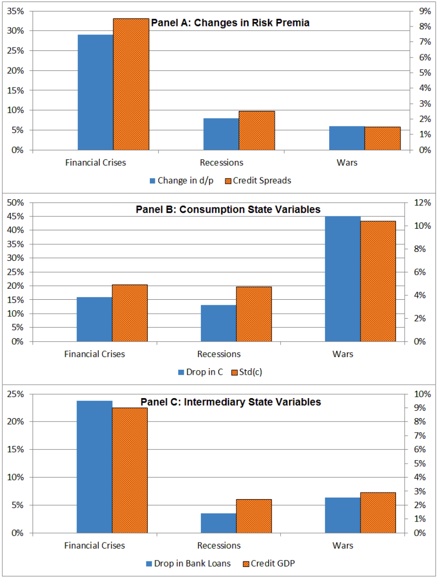
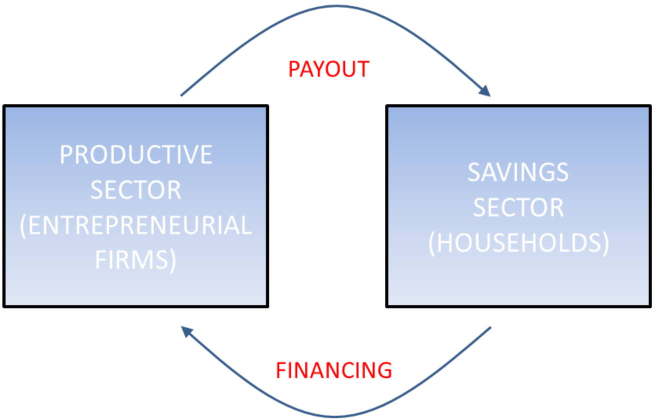
Who bears the losses is critical.

- Not representative agent. Distribution/heterogeneity matters.
- *How do shocks affect the distribution of wealth across the economy?*

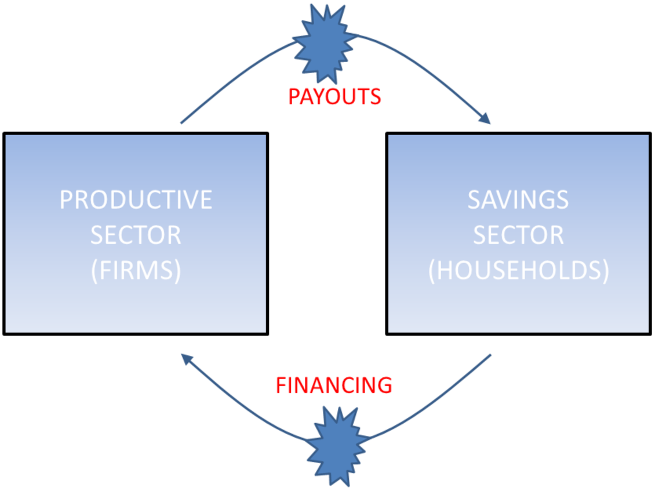
Aggregate Shocks and Risk Premia (Muir, 2014)



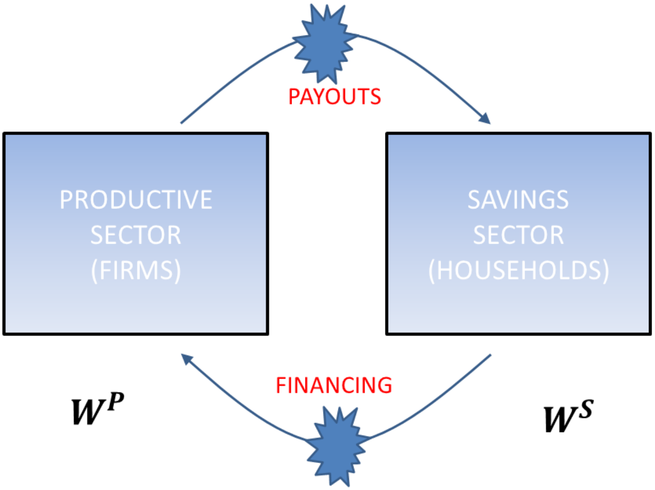
Modeling Financial Frictions in Macroeconomics



Financial Friction limits Flow of Funds



Wealth Distribution



Persistence: Bernanke-Gertler (1989), Bernanke-Gertler-Gilchrist (1999)

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

$$\begin{aligned} W_{t+1}^P &= W_t^P + \overbrace{\Pi_t}^{\text{profits}} \\ W_{t+1}^S &= W_t^S(1 + r_t) \end{aligned}$$

- Positive TFP shock increases profits Π_t, W_{t+1}^P
- Investment at $t + 1$ closer to first best as wealth shifts towards W_{t+1}^P
- Output and Π_{t+1} at $t + 1$ rise

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- **"Financial Accelerator"**: Profits Π_{t+1} rise, increase wealth W_{t+1}^P, profits Π_{t+2}...
- Credit boom
- Slow recovery, long slump (US 2009-, Japan lost decade)

Amplification: Kiyotaki-Moore (1997)

- W_t^P is a portfolio that includes long-lived assets (physical capital)
- Value of long-lived assets:

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

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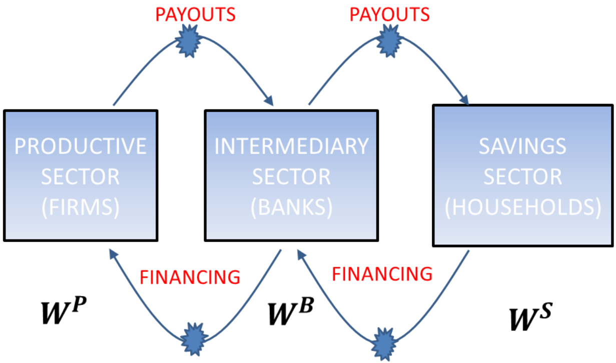
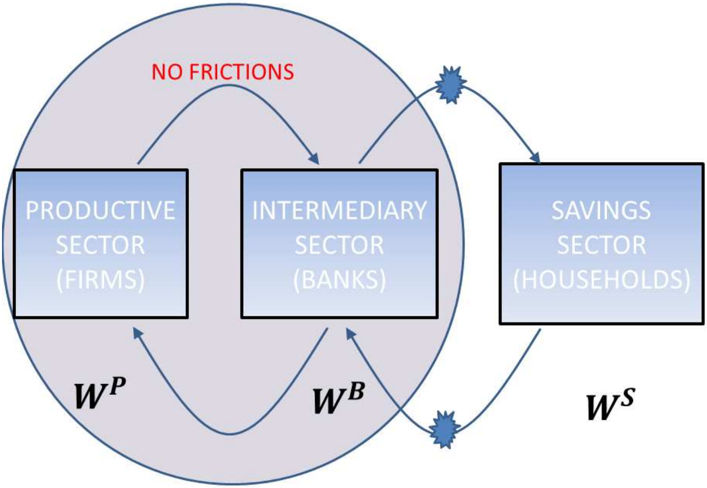
- “Pebble that started the avalanche": small shock/large effect
- Real estate and 2007-2009 financial crisis

Intermediaries Matter



- “Triple-decker models": Holmstrom-Tirole (1997), Rampini-Viswanathan (2013)
- Large empirical literature on banking channel: Bernanke (1983), Kashyap-Stein (1994), Peek-Rosengren (2000), Khwaja-Mian (2008), Schnabl (2011), Becker-Ivashina (2013), Chodorow-Reich (2013), Hilt-Frydman-Zhou (2013)

Intermediary-Firm Coalition



Finance: Discount Rate Variation

- Kiyotaki-Moore: Volatility due to cash flow variation

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- Finance perspective: R variation more important than Π variation in asset pricing.

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- Finance perspective: R variation more important than Π variation in asset pricing.
- Wealth distribution and asset prices:

  W_t^B particularly important for “intermediated" assets

Intermediary Capital: CDS-Bond Basis

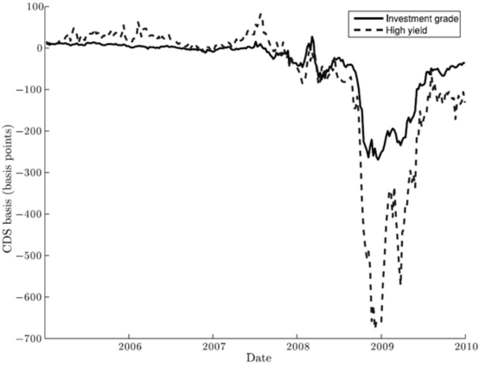

Figure 4. The corporate-bond CDS basis, the difference between the CDS rate and the associated par bond yield spread, is theoretically near zero in frictionless markets. As shown, the average CDS basis across portfolios of U.S. investment-grade bonds and high-yield bonds widened dramatically during the 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-grades 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

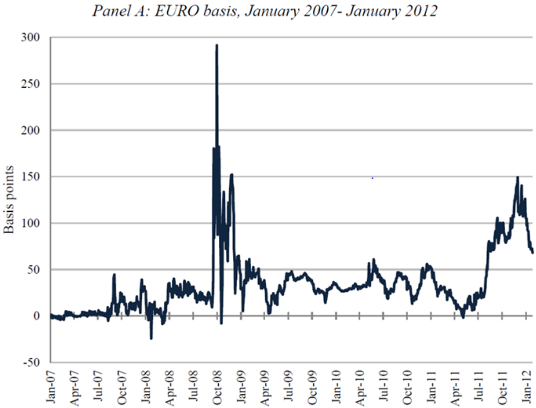

Figure 3 from Ivashina, Scharfstein and Stein (2012)

Intermediary Pricing Kernel

- 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!)

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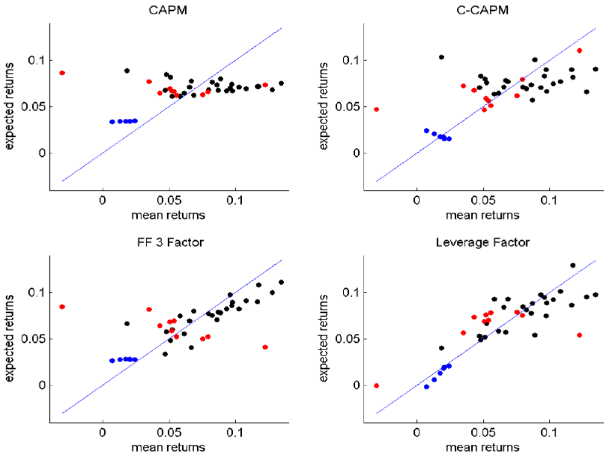

Black = FF25, Red = 10momentum, Blue = 6 Bonds

Risk Premia in Stochastic Models

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

1. 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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He-Krishnamurthy (2013)

- Two classes of agents: households and bankers
  - Households:

$$\mathbb{E}\left[\int_0^\infty e^{-\rho t}\frac{1}{1-\gamma}C_t^{1-\gamma}dt\right], \qquad C_t = \left(c_t^y\right)^{1-\phi}\left(c_t^h\right)^{\phi}$$

- 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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- Fundamental shocks: stochastic capital quality shock dZ_t. TFP shocks

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

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- Investment/Capital i_t, quadratic adjustment cost

$$\Phi(i_t, K_t) = i_t K_t + \frac{\kappa}{2}\left(i_t - \delta\right)^2 K_t$$

$$\max_{i_t}\ q_t i_t K_t - \Phi(i_t, K_t) \ \Rightarrow\ i_t = \delta + \frac{q_t - 1}{\kappa}$$

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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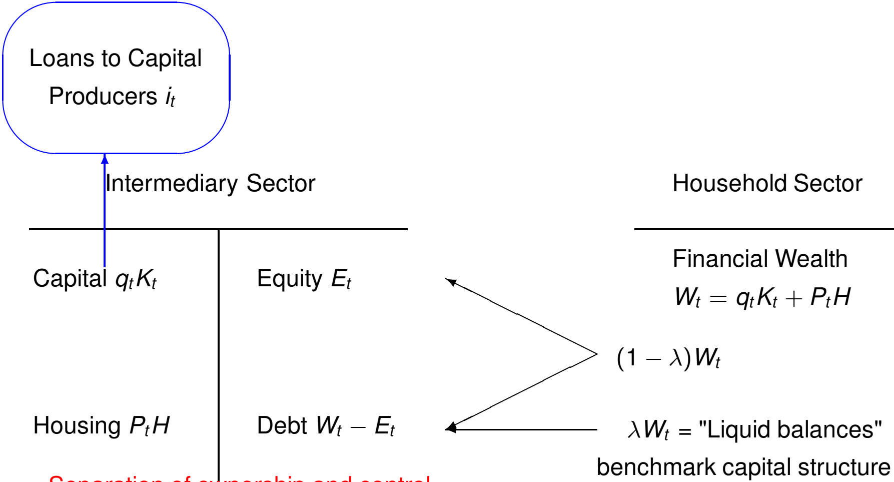
$(1 - \lambda) W_t$

λW_t = "Liquid balances"

benchmark capital structure

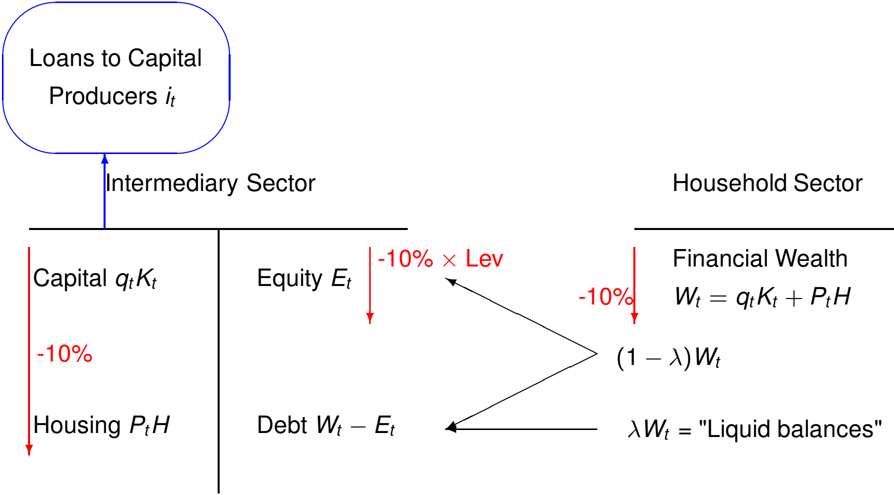
Equity Matters



Separation of ownership and control

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

Equity Dynamics in GE



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Equity Constraint

Loans to Capital Producers i_t

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

$\frac{d\mathcal{E}_t}{\mathcal{E}_t} = m\times$ ROE, ROE is endogenous

Intermediary Sector	
Capital $q_t K_t$	Equity E_t
Housing $P_t H$	Debt $W_t - E_t$

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

No constraint

Household Sector

Financial Wealth

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$(1-\lambda)W_t$

λW_t = "Liquid balances"

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Equity constraint: ϵ_t

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

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

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  - Poor returns reduce “reputation": Berk-Green, 04; flow-performance relationship, Warther 95; Chevalier-Ellison, 97
  - Or, ϵ_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 $\mathcal{E}_t = \int \epsilon_t$

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

- Exogenous death rate η. 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) λW_t and equity (at most) $(1-\lambda)W_t$
- Benchmark capital structure: λW_t of Debt, $(1-\lambda)W_t$ of Equity
  - if there is no capital constraint ($\mathcal{E}_t$ is infinite)...

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

$$E_t = \min\left[\mathcal{E}_t, (1-\lambda)W_t\right]$$

- Suppose a -10% shock to real estate and price of capital:
- $W_t \downarrow 10\%$ (Household wealth = aggregate wealth)
- Reputation: $\frac{d\mathcal{E}_t}{\mathcal{E}_t} = md\tilde{R}_t + \ldots$ Two forces make $\mathcal{E}_t \downarrow$ 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

Capital $q_t k_t$	$equity_t$
Housing $P_t h_t$	$debt_t$

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

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

Borrowing (no constraint): $debt_t = q_t k_t + P_t h_t - equity_t = (\alpha_t^k + \alpha_t^h - 1)equity_t$

Bank Choice of Portfolio and Leverage

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Return on bank equity ROE: $d\tilde{R}_t = \alpha_t^k dR_t^k + \alpha_t^h dR_t^h - (\alpha_t^k + \alpha_t^h - 1)r_t dt$

Banker (log preference) solves: $\max_{\alpha_t^k, \alpha_t^h} \mathbb{E}_t[d\tilde{R}_t - r_t dt] - \frac{m}{2} Var_t[d\tilde{R}_t]$

Bank Choice of Portfolio and Leverage

Capital $q_t k_t$	$equity_t$
Housing $P_t h_t$	$debt_t$

Properties

- (k, h) scales with *equity*
- (k, h) increasing in $\mathbb{E}_t[d\tilde{R}_t - r_t dt]$
- (k, h) decreasing in $Var_t[d\tilde{R}_t]$

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

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General Equilibrium

Intermediary Sector

Assets	Liabilities
Capital $q_t K_t$	Equity E_t
Housing $P_t H$	Debt $W_t - E_t$

Household Sector

Financial Wealth

$$W_t = q_t K_t + P_t H$$

Portfolio share in capital: $\alpha_t^k = \frac{q_t K_t}{E_t} = \frac{q_t K_t}{\min[\mathcal{E}_t, (1-\lambda) W_t]}$

Portfolio share in housing: $\alpha_t^h = \frac{P_t H}{E_t} = \frac{P_t H}{\min[\mathcal{E}_t, (1-\lambda) W_t]}$

- Given state $(K_t, \mathcal{E}_t)$, the equilibrium portfolio shares are pinned down by GE
- But portfolio shares must also be optimally chosen by banks, pinning down prices

$$\max_{\alpha_t^k, \alpha_t^h} \quad \mathbb{E}_t[d\tilde{R}_t - r_t dt] - \frac{m}{2} Var_t[d\tilde{R}_t]$$

- Asset prices affect real side through investment (q_t)

General Equilibrium (2)

Intermediary Sector

Capital $q_t K_t$	Equity E_t
Housing $P_t H$	Debt $W_t - E_t$

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

Household Sector

Financial Wealth

$W_t = q_t K_t + P_t H$

Portfolio share in capital: $\alpha_t^k = \frac{q_t K_t}{E_t} = \frac{q_t K_t}{\min[\mathcal{E}_t,(1-\lambda)W_t]}$

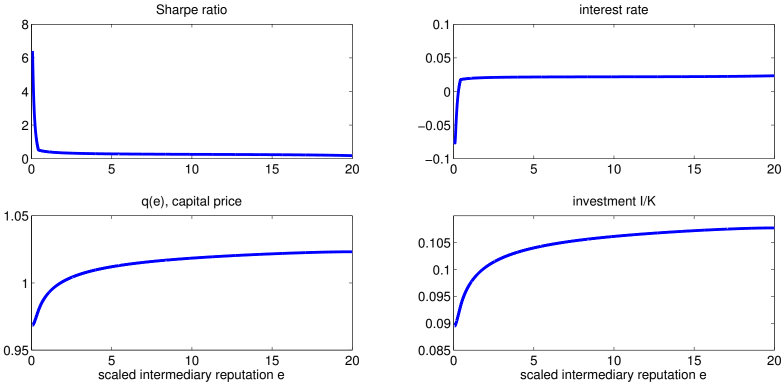
Portfolio share in housing: $\alpha_t^k = \frac{P_t H}{E_t} = \frac{P_t H}{\min[\mathcal{E}_t,(1-\lambda)W_t]}$

- Prices (returns) have to adjust for optimality:
  - $\mathbb{E}_t[dR_t^h - r_t dt], \mathbb{E}_t[dR_t^k - r_t dt] \Rightarrow$ equations for $\mathbb{E}_t[dP_t], \mathbb{E}_t[dq_t]$
- Rewrite to get Partial Differential Equations for $P(K, \mathcal{E})$ and $q(K, \mathcal{E})$
- Scale invariance: Define $e \equiv \mathcal{E}/K$; then $P = Kp(e)$ and $q(e)$, PDEs become ODEs

Calibration: Baseline Parameters

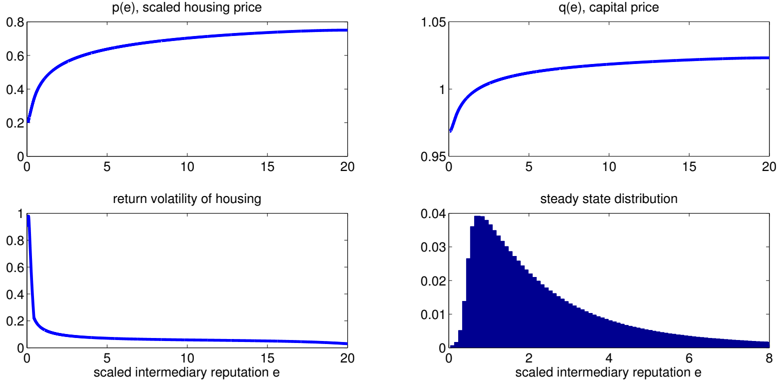
	Parameter	Choice	Targets (Unconditional)
Panel A: Intermediation			
m	Performance sensitivity	2	Average Sharpe ratio (model=38%)
λ	Debt ratio	0.67	Average intermediary leverage
η	Banker exit rate	13%	Prob. of crisis (model,data = 3%)
γ	Entry trigger	6.5	Highest Sharpe ratio
β	Entry cost	2.43	Average land price vol (model,data=14%)
Panel B: Technology			
σ	Capital quality shock	3%	Consumption volatility (model=1.4%)
			Note: Model investment vol = 4.5%
δ	Depreciation rate	10%	Literature
κ	Adjustment cost	3	Literature
A	Productivity	0.133	Average investment-to-capital ratio
Panel C: Others			
ρ	Time discount rate	2%	Literature
ξ	1/EIS	0.15	Interest rate volatility
ϕ	Housing share	0.5	Housing-to-wealth ratio

Results(1): State variable is $e_t = \mathcal{E}_t / K_t$



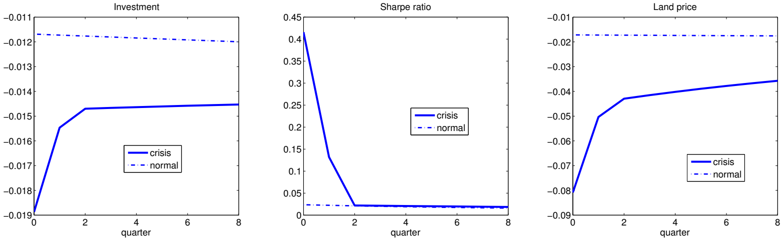
- Capital constraint binds for $e < 0.435$

Results(2)

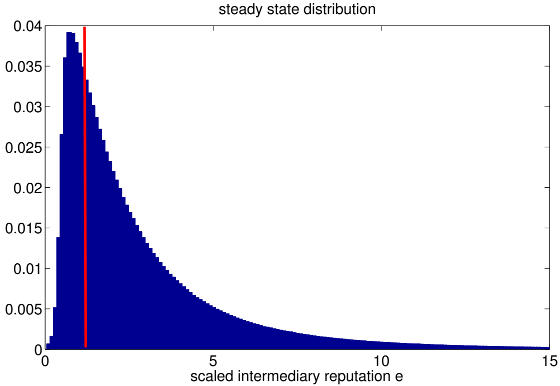


- Capital constraint binds for $e < 0.435$
- Without the possibility of the capital constraint, all of these lines would be flat. Model dynamics would be i.i.d., with vol=3%. Endogenously time-varying “uncertainty."

State-dependent Impulse Response: -1% Shock ($= \sigma dZ_t$) ▸ VARdata



Steady State Distribution



Nonlinearities in Model and Data

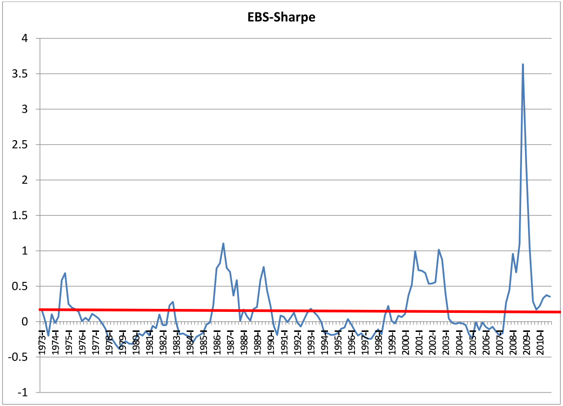
Model:

- 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

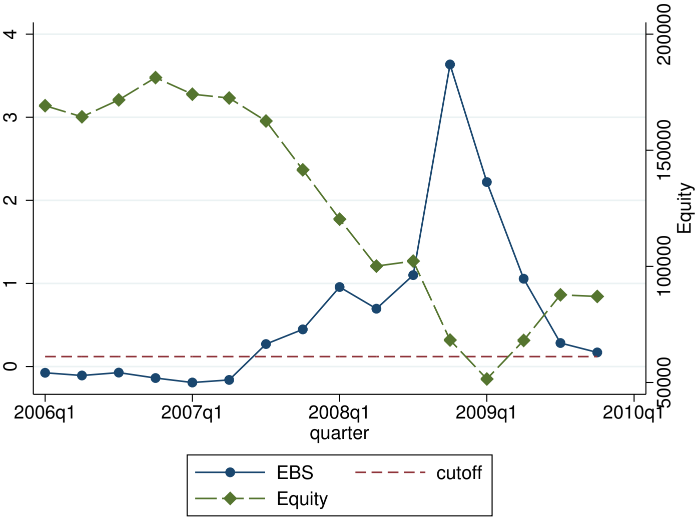


Matching State-Dependent Covariances

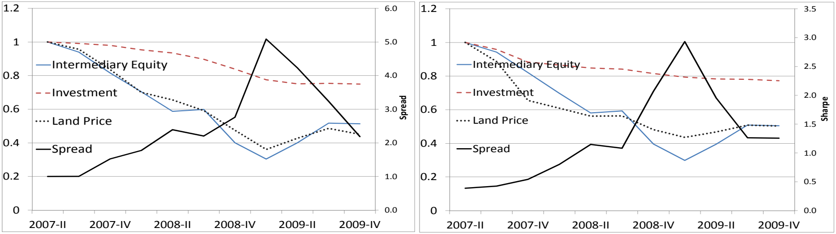
	Distress		Non Distress	
	Data	Baseline	Data	Baseline
$vol\,(Eq)$	31.48%	34.45	17.54	5.4
$vol\,(I)$	8.05%	5.30	6.61	4.2
$vol\,(C)$	1.71%	3.54	1.28	1.19
$vol\,(LP)$	21.24%	21.04	9.79	9.24
$vol\,(EB)$	60.14%	74.20	12.72	7.97
$cov\,(Eq, I)$	1.31%	1.05	0.07	0.23
$cov\,(Eq, C)$	0.25%	-0.96	0.03	-0.05
$cov\,(Eq, LP)$	4.06%	5.87	0.12	0.5
$cov\,(Eq, EB)$	-6.81%	-14.95	-0.14	-0.13

- Note: without the capital constraint, all volatilities would be 3%, and have no state dependence.
- What we do badly on: Output vol is locally σ because $Y_t = AK_t$. Financial friction only affects split between I and C.

Matching the 2007-2009 Crisis



Matching Recent Crisis: *Data(L) and Model(R)*



- 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.

07QIII	07QIV	08QI	08QII	08QIII	08QIV	09QI	09QII	09QIII	09QIV
-2.5%	-4.2	-1.1	-1.1	-0.7	-1.6	-1.8	-1.8	-0.9	-0.9

  - 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

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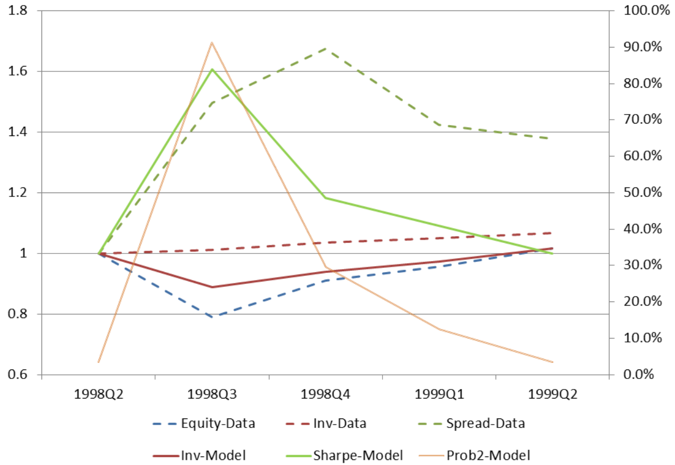
Open questions...

1998 LTCM Crisis



- 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.
- 1987,1998: Is it adequate policy response?
- Is it that the corporate sector is able to bypass the intermediary sector problems? ("triple-decker model")

Financial and Real Shocks

- 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.

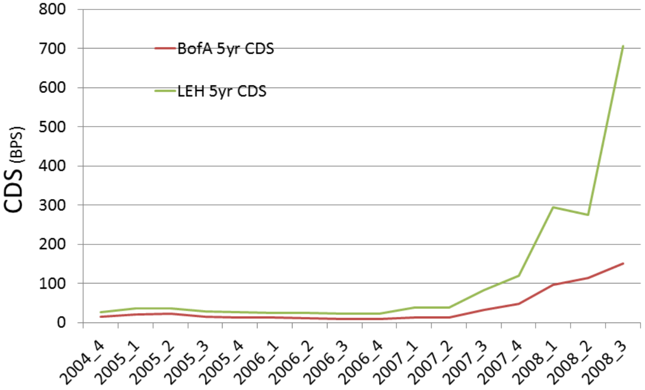
Financial and Real Variables (from Krishnamurthy-Muir)

Financial Crises

Outcome variable	Mean	Median	Std Dev	10th	90th
Duration (GDP)	**5.9**	**4.0**	5.6	1	15
Spread Duration	**3.1**	**1.0**	3.6	0	10

- Financial variables settle back more quickly than real variables.
- Two state variables...

CDS and Build-up



Forecasting Crises (from Krishnamurthy-Muir)

$$depth_{i,t} = \alpha + b \times spread_{i,t} + \varepsilon_{i,t}$$

ST Dates	b	se(b)	$\sigma\,(b \times spread_{i,t})$	AdjR^2	N
All	-0.76	0.26	7.8	27%	23
No Depression	-1.24	0.25	5.3	61%	16

RR Dates	b	se(b)	$\sigma\,(b \times spread_{i,t})$	AdjR^2	N
All	-1.32	0.14	8.6	87%	15
No Depression	-1.39	0.20	6.7	78%	13

- $depth_{i,t}$ = Peak to trough decline in GDP
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$$spread_{i,t} = 0.9 \times spread_{i,t-1} + u_t$$

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

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
- Monetary models: monetary policy shocks affects risk premia (Hanson-Stein 2013, Nakamura-Steinsson 2013, Drechsler-Savov-Schnabl, 2014)