A Macroeconomic Model with Financially Constrained Producers and Intermediaries

Vadim Elenev[1] Tim Landvoigt[2] Stijn Van Nieuwerburgh[3]

[1]NYU Stern

[2]UT Austin

[3]NYU Stern, NBER, and CEPR

FRBSF Conference on Macroeconomics and Monetary Policy,
March 31, 2017

Motivation

- Great Recession underscored importance of financial sector for broader economy:
  - Bank insolvencies and government bailouts
  - High credit spreads and low real interest rates
  - Disruptions in financial intermediation fed back on the real economy
  - Investment, output, and consumption all fell substantially and persistently

Motivation

- Great Recession underscored importance of financial sector for broader economy:

- Until recently, standard macroeconomic models had limited role for financial sector
  - Pre-1990: Quantitative macro literature mostly focuses on interaction between savers and borrowers without explicit role for financial intermediaries (veil)
  - 1990s: Kiyotaki & Moore and Bernanke, Gertler, & Gilchrist emphasize amplification of macro shocks by frictions in credit markets
  - Recently: He & Krishnamurthy (12), Brunnermeier & Sannikov (14) solve model non-linearly, but at the expense of quantitative realism
  - This work assumes that banks own equity-like claims on firms

Our Contribution

- Introduce a financial sector which intermediates between firms/entrepreneurs and savers

Our Contribution

- Introduce a financial sector which intermediates between firms/entrepreneurs and savers
- Balance sheet of borrower-entrepreneurs and banks are **decoupled**
  - Intermediaries make risky **loans** to firms/entrepreneurs
  - Credit losses hurt banks' balance sheets
  - Affecting ability of banks to lend to entrepreneurs
  - And entrepreneurs' ability to invest $\Rightarrow$ low economic output
  - Slowly recovering intermediary wealth causes deeper recessions

Our Contribution

- Introduce a financial sector which intermediates between firms/entrepreneurs and savers
- Balance sheet of borrower-entrepreneurs and banks are **decoupled**
- Introduce possibility of systemic financial sector insolvency
  - Requires modeling government bank bailouts
  - Introduces interconnectedness of government and financial system

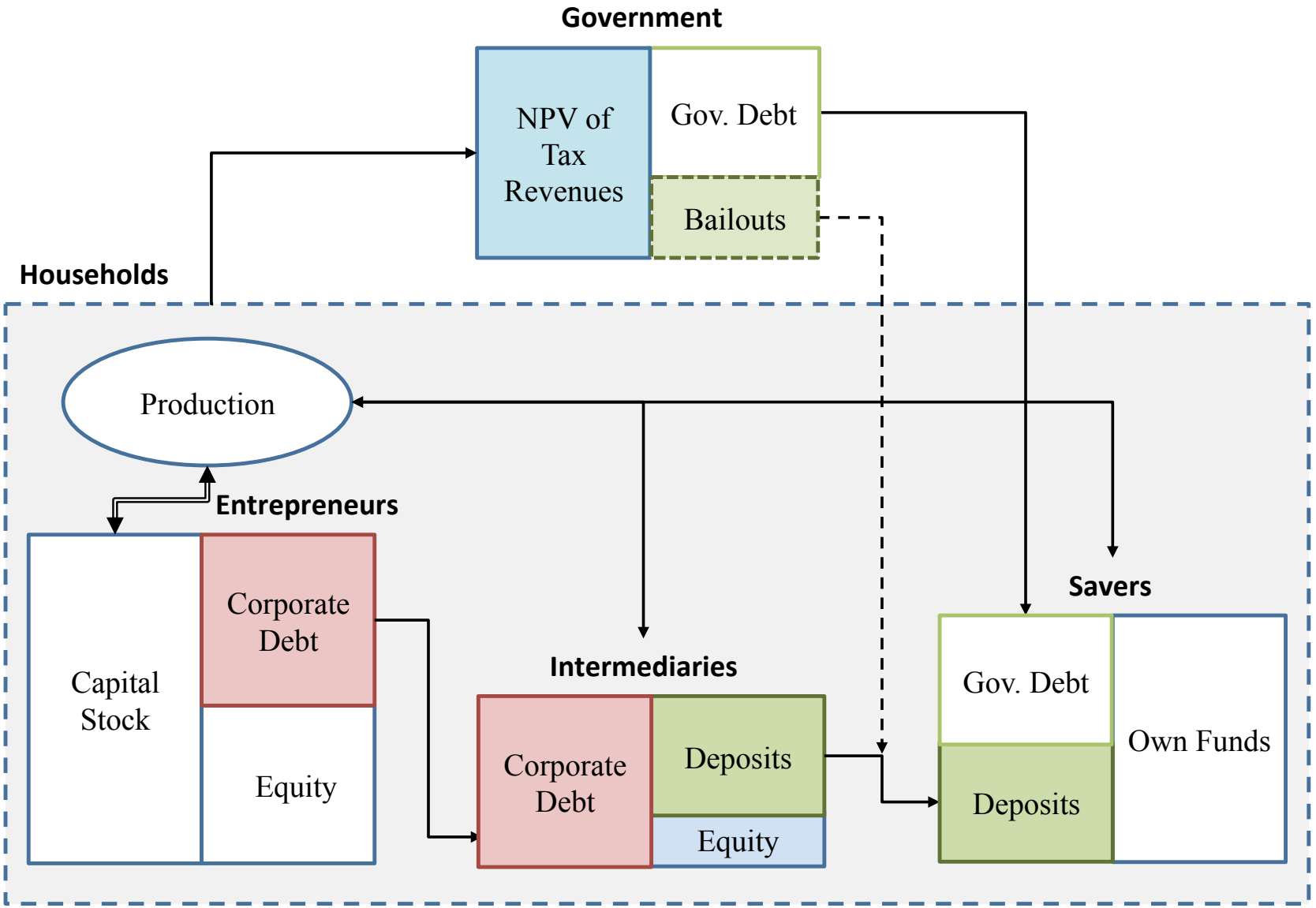
Our Contribution

- Introduce a financial sector which intermediates between firms/entrepreneurs and savers
- Balance sheet of borrower-entrepreneurs and banks are **decoupled**
- Introduce possibility of systemic financial sector insolvency
- Endogenize the demand for safe assets: effect on bank recapitalization from low rates in crisis

Our Contribution

- Introduce a financial sector which intermediates between firms/entrepreneurs and savers
- Balance sheet of borrower-entrepreneurs and banks are **decoupled**
- Introduce possibility of systemic financial sector insolvency
- Endogenize the demand for safe assets: effect on bank recapitalization from low rates in crisis
- **Macroprudential policy** experiment for bank capital requirement:
  - Trade-off between **volatility** and **size of economy**
  - Tighter macro-prudential policy has modest aggregate welfare gain
  - Tighter macro-prudential policy benefits bank share holders

Model Overview



Borrower-Entrepreneurs

- Preferences: Epstein-Zin preferences
  - EIS is ν^B, patience is β^B, risk aversion is σ^B
  - Relative impatient and relatively risk tolerant
- Technology:
  - Produce consumption goods: $Y_t = (Z_t L_t)^{\alpha} K_t^{1-\alpha}$
    - ★ Labor provided inelastically by all household types: $L_t = (L_t^B)^{1-\gamma_S-\gamma_I}(L_t^S)^{\gamma_S}(L_t^I)^{\gamma_I}$
    - ★ **Productivity growth first source of aggregate risk**: $\Delta \log(Z_t) \equiv g_t = (1-\rho_g)\bar{g} + \rho_g g_{t-1} + \epsilon_t$
  - Produce new capital goods from consumption goods
    - ★ Creating X_t capital goods requires $X_t + \Psi(X_t/K_t^B)K_t^B$,
    - ★ $\Psi(\cdot)$ is standard convex adjustment cost

Borrower-Entrepreneurs

- Entrepreneurs are hit with idiosyncratic productivity shocks $\omega_{i,t} \sim F_{\omega,t}$, indep. distr. over time
  - Cross-sectional dispersion $\sigma_{\omega,t}$ follows 2-state Markov chain, **second source of aggregate risk** – *uncertainty shock*
  - Can be correlated with TFP growth shock; $Cov(\sigma_{\omega,t}, g_t) < 0$

Borrower-Entrepreneurs

- Entrepreneurs are hit with idiosyncratic productivity shocks $\omega_{i,t} \sim F_{\omega,t}$, indep. distr. over time

- Entrepreneurs obtain corporate loans/bonds to finance investment
  - Corporate loans/bonds are long-term with default risk
    - ★ Loan modeled as geometrically δ-decaying perpetuity; face value F
    - ★ Tax shield for interest payments (and capital depreciation)
    - ★ Borrowing constraint on firm leverage with max LTV Φ: $FA^B_{t+1} \leq \Phi p_t (1-\delta_K) Z_A(\omega^*_t) K^B_t$

Borrower-Entrepreneurs

- Entrepreneurs are hit with idiosyncratic productivity shocks $\omega_{i,t} \sim F_{\omega,t}$, indep. distr. over time

- Entrepreneurs obtain corporate loans/bonds to finance investment
  - Corporate loans/bonds are long-term with default risk

  - Each entrepreneurs follows debt repayment rule
    - ★ Default on indiv. piece of debt if profit $\pi(\omega_{i,t}) < 0$
    - ★ Model of *liquidity default* (as opposed to strategic default)
    - ★ Default triggers liquidation: bank seizes bankrupt firm and unwinds it
    - ★ Equilibrium default threshold ω_t^* for individual entrepreneurs
    - ★ Leverage endogenously limited through costly bankruptcies: borrower-entrepreneurs internalize effect of time-t choices on ω_{t+1}^*

Intermediaries

- Same preferences as borrower-entrepreneurs
- Have option to declare bankruptcy
  - Government assumes all assets and liabilities of bank
  - Bails out creditors of intermediaries
  - Intermediary bankruptcy = limited liability = deposit insurance
- Choose how many new corporate loans to make A^I_{t+1}
  - Coupon payment on performing loans: $Z_A(\omega^*_t)A^I_t$
  - Firms that default go into liquidation: recovery is (DWL ζ)

$$(1-\zeta)\left[(1-Z_A(\omega^*_t))(1-\delta_K)p_tK^B_t + (1-Z_K(\omega^*_t))(K^B_t)^{1-\alpha}L^\alpha_t\right] - (1-Z_A(\omega^*_t))\sum_j w^j_t L^j_t$$

- Choose how many deposits to issue B^I_t, subject to Basel-style regulatory bank capital constraint with parameter ξ:

$$-B^I_t \leq \xi q^m_t A^I_{t+1}$$

- Pay for deposit insurance (κ), taxed on net interest income

▸ Complete Problem

Savers and Government

- **Savers**
  - Also Epstein-Zin preferences
  - High patience, risk aversion, and EIS
  - Only invest in risk free bonds, $B_t^S \geq 0$

- **Government** follows passive tax and spending rule
  - Revenues T_t: tax on labor income, on corporate and intermediary profit, revenue from deposit insurance
  - Expenditures G_t: discretionary (G_t^o), transfer, intermediary bailouts
  - Budget constraint (govmt. debt policy)

$$T_t + q_t^f B_t^G = B_{t-1}^G + G_t$$

  - Tax rate adjusts at the extremes to ensure B^G stays bounded

Competitive Equilibrium

- Given prices and government policy parameters $\Theta_t = \left(\tau_t^i, \tau_\Pi^i, G_t^o, \Phi, \xi, \kappa\right)$, all three household types maximize their value functions subject to their budget and borrowing constraints
- Markets clear
  - Risky, long-term corporate loan/bond market
  - Riskfree, short-term bond market (deposits/govmt debt)
  - Capital market (Tobin's q)
  - Labor market for each of three types of households
- Resource constraint:

$$Y_t = \underbrace{\underbrace{\underbrace{C_t^B + C_t^I + C_t^S}_{CONS_t} + \underbrace{G_t^o}_{GOV_t} + \underbrace{X_t + \Psi(X_t/K_t^B)K_t^B}_{INV_t}}_{GDP_t} + DWL_t}$$

State Variables and Solution Method

- Exogenous states
  - Persistent aggregate TFP growth rate g_t
  - Dispersion of idiosyncr. productivity (*uncertainty*) $\sigma_{\omega,t}$
- Five endogenous states: capital, corp. debt, govt. debt, deposits, intermediary wealth
  - Wealth distribution matters for asset prices due to incomplete markets
  - **Intermediary wealth** is a key state variable
- Nonlinear global solution method – policy time iteration
  - Two collateral constraints occasionally binding
  - Changing wealth distribution causes time-variation in risk premia
  - Non-linear dynamics when intermediaries are constrained

Calibration Highlights

1. Corporate loan duration δ and face value $F = \frac{\alpha}{1-\delta}$ to match price, WAC, WAM of geometric bond to blend of IG and HY indices
2. Two states of credit risk $[\sigma_{\omega,lo}, \sigma_{\omega,hi}] = [0.1, 0.17]$, deadweight loss from default $\zeta = 0.5$, and transition matrix P^{ω}
   - to match average default and severity rates on corporate debt
   - and frequency and length of credit crises (Reinhart and Rogoff)
3. Set borrower and intermediary patience $\beta_B = \beta_I = 0.95$ to match corporate leverage
4. Set saver risk aversion $\sigma_S = 20$ to match high financial sector leverage
5. Set intermediary margin $\xi = 95\%$ to risk-weighted cap requirement
5. Target mean and vol of investment/output, mean and vol of r^f
6. Detailed matching of govt. tax and revenue components and their cyclicality

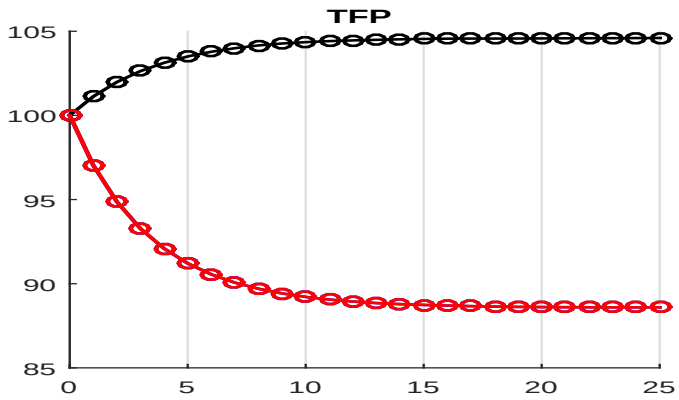
Main Results: Macro Quantities

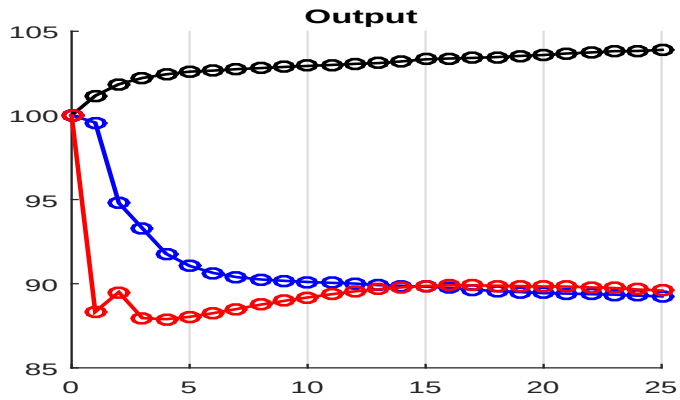
- Long simulation of model, tables show means and standard deviations across states of the world
- Model comes close to matching mean, vol, and AC of GDP cycle
- Does reasonable job on other major macro quantities

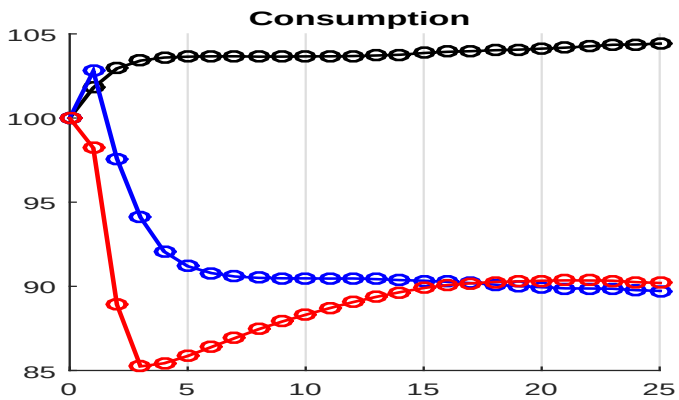
	mean	stdev	output corr.	AC		stdev
			Data			
GDP^{hp}		2.13%	1.00	0.68	$\Delta \log(GDP)$	1.94%
INV^{hp}		6.31%	0.77	0.58	$\Delta \log(INV)$	6.14%
$CONS^{hp}$		1.87%	0.91	0.65	$\Delta \log(CONS)$	1.78%
GOV^{hp}		3.73%	0.46	0.78	$\Delta \log(GOV)$	2.53%
INV/K	10.5%	0.89%	0.44	0.82		
INV/GDP	13.3%	1.23%	0.19	0.87		
			Model			
GDP^{hp}		2.45%	1.00	0.56	$\Delta \log(GDP)$	2.59%
INV^{hp}		5.71%	0.59	0.09	$\Delta \log(INV)$	7.95%
$CONS^{hp}$		2.67%	0.83	0.67	$\Delta \log(CONS)$	2.92%
GOV^{hp}		1.79%	0.69	0.31	$\Delta \log(GOV)$	2.52%
INV/K	9.59%	0.85%	0.36	0.68		
INV/GDP	21.14%	1.08%	0.10	0.37		

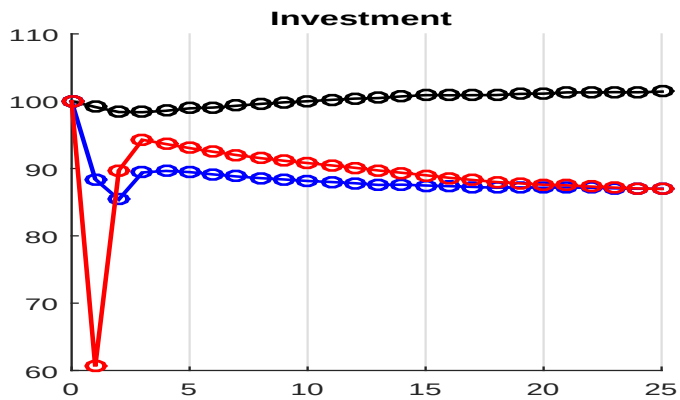
Boom-Bust: Macro Quantities

- Period 1: Shock from highest to lowest TFP realization + uncertainty shock (high σ_ω) or not (low σ_ω)
- Financial vs. non-financial recession vs. unconditional path









Corporate Balance Sheet Variables

- Modest leverage ratio for non-financial corporations
- Book leverage pro-cyclical, market leverage counter-cyclical
- Leverage (LTV) constraint only occasionally binds, in fin. recessions
- Matches mean default and loss-given-default rate
- Tobin's q falls sharply in fin. crises: fire sales
- Corporate bond rate increases: higher default risk and risk premia

	Unconditional		**Expansions**	**Non-fin Rec.**	**Fin Rec.**
	mean	stdev	mean	mean	mean
Book leverage ratio	53.59%	8.23%	59.00%	52.95%	44.18%
Market leverage ratio	53.68%	6.82%	54.43%	52.97%	54.59%
% leverage constr binds	1.73%	13.05%	0.00%	0.00%	11.58%
Default rate	2.59%	2.51%	1.75%	1.68%	7.62%
Loss-given-default rate	39.29%	12.42%	37.83%	39.54%	41.61%
Loss Rate	1.18%	1.93%	0.69%	0.70%	3.92%
Tobin's q	1.002	0.112	1.083	1.000	0.836
Corporate bond rate	4.60%	0.44%	4.60%	4.49%	4.96%

Corporate Balance Sheet Variables

- Modest leverage ratio for non-financial corporations
- Book leverage pro-cyclical, market leverage counter-cyclical
- Leverage (LTV) constraint only occasionally binds, in fin. recessions
- Matches mean default and loss-given-default rate
- Tobin's q falls sharply in fin. crises: fire sales
- Corporate bond rate increases: higher default risk and risk premia

	Unconditional		**Expansions**	**Non-fin Rec.**	**Fin Rec.**
	mean	stdev	mean	mean	mean
Book leverage ratio	53.59%	8.23%	59.00%	52.95%	44.18%
Market leverage ratio	53.68%	6.82%	54.43%	52.97%	54.59%
% leverage constr binds	1.73%	13.05%	0.00%	0.00%	11.58%
Default rate	2.59%	2.51%	1.75%	1.68%	7.62%
Loss-given-default rate	39.29%	12.42%	37.83%	39.54%	41.61%
Loss Rate	1.18%	1.93%	0.69%	0.70%	3.92%
Tobin's q	1.002	0.112	1.083	1.000	0.836
Corporate bond rate	4.60%	0.44%	4.60%	4.49%	4.96%

Corporate Balance Sheet Variables

- Modest leverage ratio for non-financial corporations
- Book leverage pro-cyclical, market leverage counter-cyclical
- Leverage (LTV) constraint only occasionally binds, in fin. recessions
- Matches mean default and loss-given-default rate
- Tobin's q falls sharply in fin. crises: fire sales
- Corporate bond rate increases: higher default risk and risk premia

	Unconditional		**Expansions**	**Non-fin Rec.**	**Fin Rec.**
	mean	stdev	mean	mean	mean
Book leverage ratio	53.59%	8.23%	59.00%	52.95%	44.18%
Market leverage ratio	53.68%	6.82%	54.43%	52.97%	54.59%
% leverage constr binds	1.73%	13.05%	0.00%	0.00%	11.58%
Default rate	2.59%	2.51%	1.75%	1.68%	7.62%
Loss-given-default rate	39.29%	12.42%	37.83%	39.54%	41.61%
Loss Rate	1.18%	1.93%	0.69%	0.70%	3.92%
Tobin's q	1.002	0.112	1.083	1.000	0.836
Corporate bond rate	4.60%	0.44%	4.60%	4.49%	4.96%

Corporate Balance Sheet Variables

- Modest leverage ratio for non-financial corporations
- Book leverage pro-cyclical, market leverage counter-cyclical
- Leverage (LTV) constraint only occasionally binds, in fin. recessions
- Matches mean default and loss-given-default rate
- Tobin's q falls sharply in fin. crises: fire sales
- Corporate bond rate increases: higher default risk and risk premia

	Unconditional		**Expansions**	**Non-fin Rec.**	**Fin Rec.**
	mean	stdev	mean	mean	mean
Book leverage ratio	53.59%	8.23%	59.00%	52.95%	44.18%
Market leverage ratio	53.68%	6.82%	54.43%	52.97%	54.59%
% leverage constr binds	1.73%	13.05%	0.00%	0.00%	11.58%
Default rate	2.59%	2.51%	1.75%	1.68%	7.62%
Loss-given-default rate	39.29%	12.42%	37.83%	39.54%	41.61%
Loss Rate	1.18%	1.93%	0.69%	0.70%	3.92%
Tobin's q	1.002	0.112	1.083	1.000	0.836
Corporate bond rate	4.60%	0.44%	4.60%	4.49%	4.96%

Intermediary Balance Sheet Variables

- Matches high leverage of financial sector
- Book lvg. pro- and mkt lvg. counter-cyclical, as in data
- Bank leverage constraint binds often, esp. in fin. crises
- Low excess returns generate some bank insolvencies in fin recessions
- High credit spread in fin. recessions; low real rate

	Unconditional		**Expansions**	**Non-fin Rec.**	**Fin Rec.**
	mean	stdev	mean	mean	mean
Book leverage ratio	88.95%	4.27%	90.80%	88.38%	86.95%
Market leverage ratio	90.37%	4.63%	92.37%	88.96%	91.04%
% leverage constr binds	17.29%	37.81%	28.64%	5.57%	34.07%
Intermediary failure	1.82%	13.38%	0.19%	0.25%	10.91%
Risk-free rate	1.86%	2.19%	2.73%	1.94%	-0.33%
Credit spread	2.74%	2.16%	1.88%	2.55%	5.29%
Excess return on loans	1.56%	5.93%	1.25%	2.24%	-0.14%

Intermediary Balance Sheet Variables

- Matches high leverage of financial sector
- Book lvg. pro- and mkt lvg. counter-cyclical, as in data
- Bank leverage constraint binds often, esp. in fin. crises
- Low excess returns generate some bank insolvencies in fin recessions
- High credit spread in fin. recessions; low real rate

	Unconditional		**Expansions**	**Non-fin Rec.**	**Fin Rec.**
	mean	stdev	mean	mean	mean
Book leverage ratio	88.95%	4.27%	90.80%	88.38%	86.95%
Market leverage ratio	90.37%	4.63%	92.37%	88.96%	91.04%
% leverage constr binds	17.29%	37.81%	28.64%	5.57%	34.07%
Intermediary failure	1.82%	13.38%	0.19%	0.25%	10.91%
Risk-free rate	1.86%	2.19%	2.73%	1.94%	-0.33%
Credit spread	2.74%	2.16%	1.88%	2.55%	5.29%
Excess return on loans	1.56%	5.93%	1.25%	2.24%	-0.14%

Intermediary Balance Sheet Variables

- Matches high leverage of financial sector
- Book lvg. pro- and mkt lvg. counter-cyclical, as in data
- Bank leverage constraint binds often, esp. in fin. crises
- Low excess returns generate some bank insolvencies in fin recessions
- High credit spread in fin. recessions; low real rate

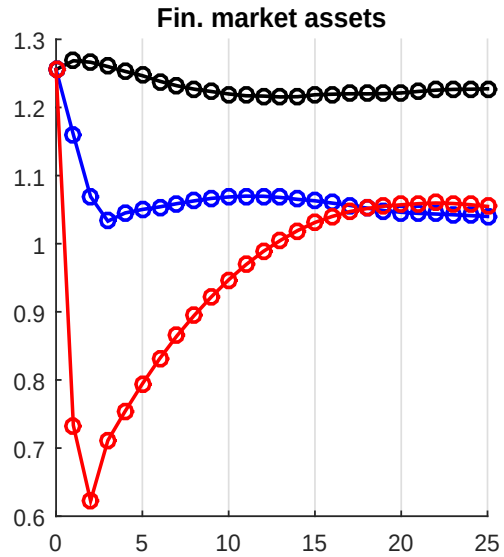
	Unconditional		**Expansions**	**Non-fin Rec.**	**Fin Rec.**
	mean	stdev	mean	mean	mean
Book leverage ratio	88.95%	4.27%	90.80%	88.38%	86.95%
Market leverage ratio	90.37%	4.63%	92.37%	88.96%	91.04%
% leverage constr binds	17.29%	37.81%	28.64%	5.57%	34.07%
Intermediary failure	1.82%	13.38%	0.19%	0.25%	10.91%
Risk-free rate	1.86%	2.19%	2.73%	1.94%	-0.33%
Credit spread	2.74%	2.16%	1.88%	2.55%	5.29%
Excess return on loans	1.56%	5.93%	1.25%	2.24%	-0.14%

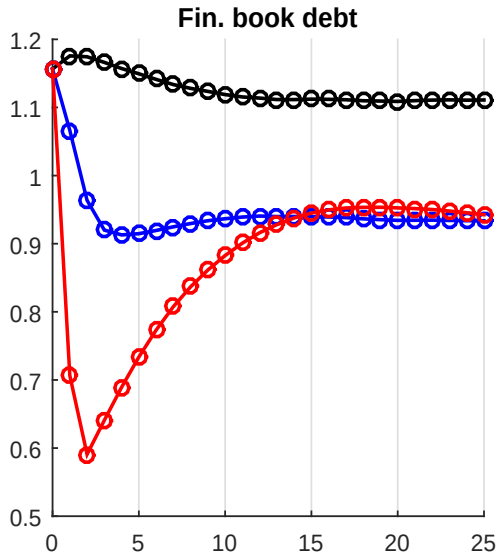
Intermediary Balance Sheet Variables

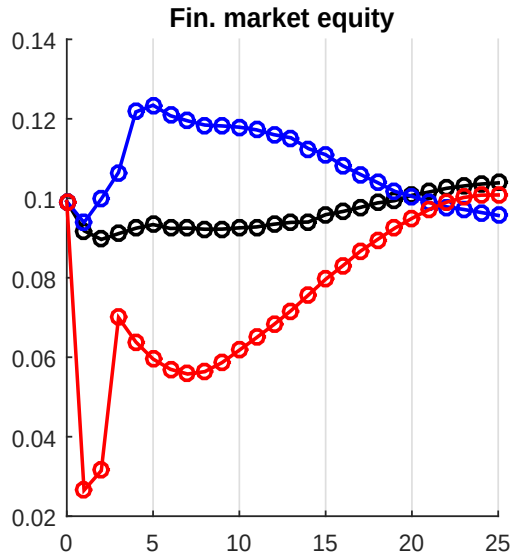
- Matches high leverage of financial sector
- Book lvg. pro- and mkt lvg. counter-cyclical, as in data
- Bank leverage constraint binds often, esp. in fin. crises
- Low excess returns generate some bank insolvencies in fin recessions
- High credit spread in fin. recessions; low real rate

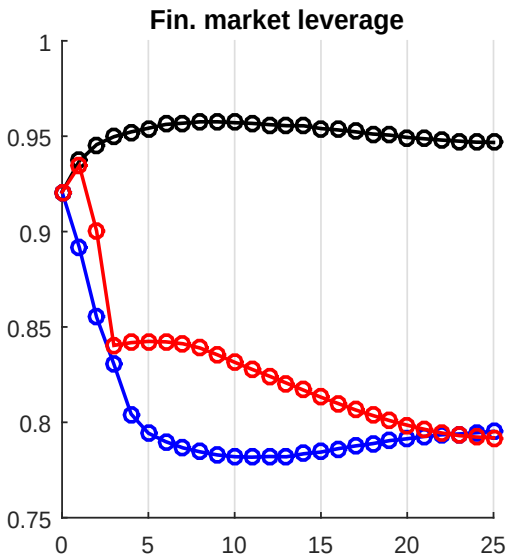
	Unconditional		**Expansions**	**Non-fin Rec.**	**Fin Rec.**
	mean	stdev	mean	mean	mean
Book leverage ratio	88.95%	4.27%	90.80%	88.38%	86.95%
Market leverage ratio	90.37%	4.63%	92.37%	88.96%	91.04%
% leverage constr binds	17.29%	37.81%	28.64%	5.57%	34.07%
Intermediary failure	1.82%	13.38%	0.19%	0.25%	10.91%
Risk-free rate	1.86%	2.19%	2.73%	1.94%	-0.33%
Credit spread	2.74%	2.16%	1.88%	2.55%	5.29%
Excess return on loans	1.56%	5.93%	1.25%	2.24%	-0.14%

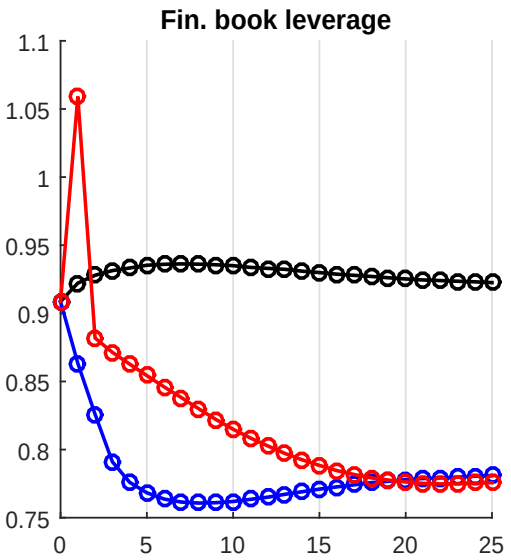
Boom-Bust: Balance Sheets of Intermediaries

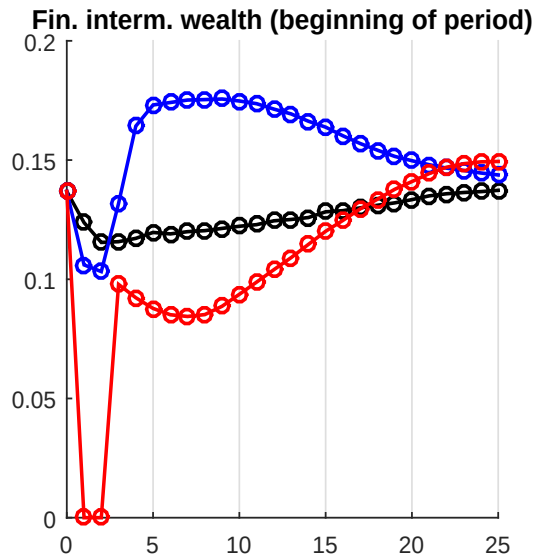




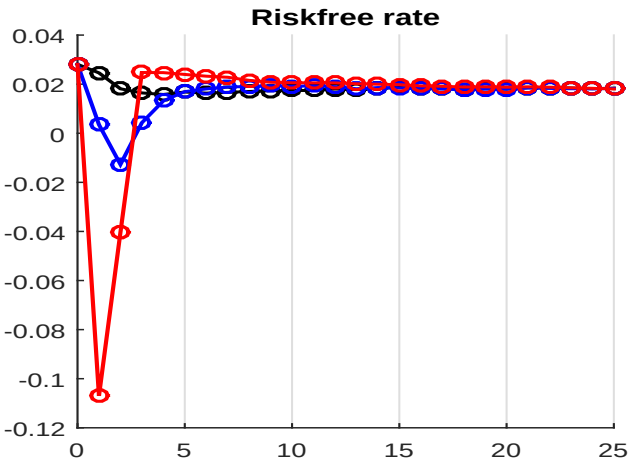


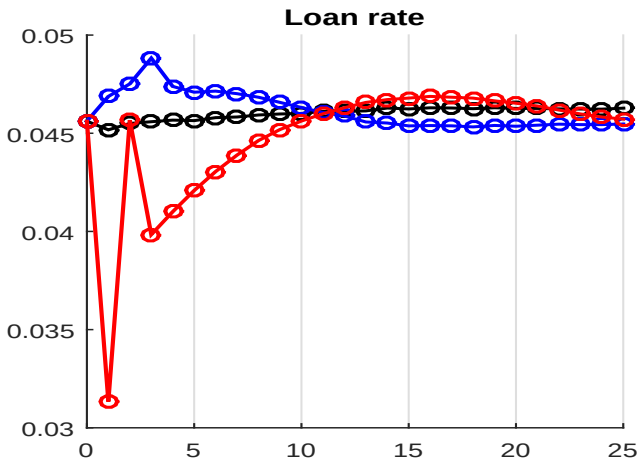


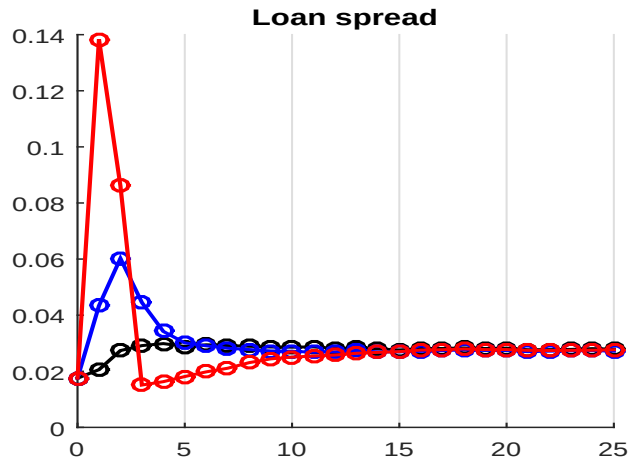


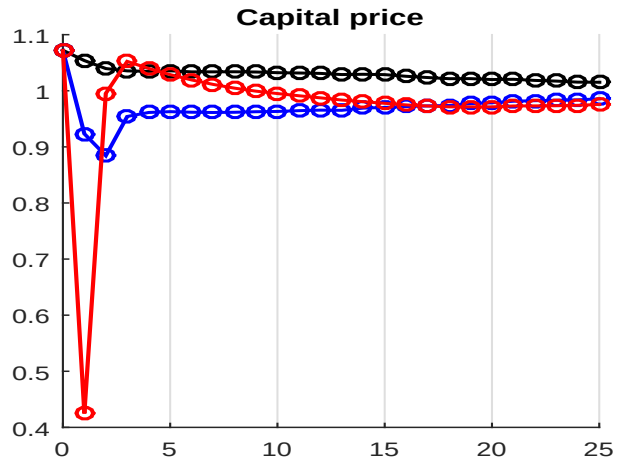


Boom-Bust: Prices



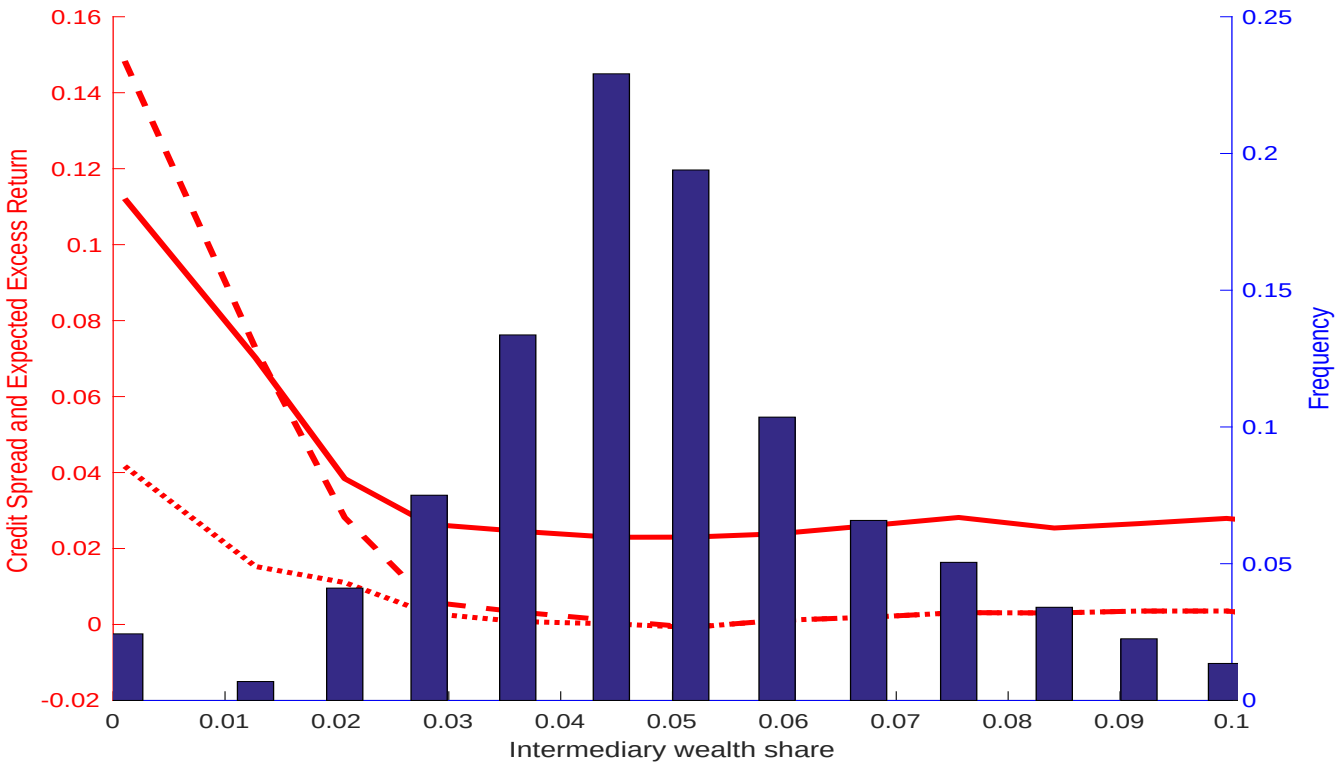






Nonlinear Dynamics and Risk Premia

- Model "solves" credit spread puzzle: 2.7% in model vs. 2.4% in data
- Intermediary wealth share important driver of the credit spread
- Credit spread reflects risk-neutral expected loss and risk premium
- Expected excess return = risk premium + constraint tightness



Macro-prudential policy

- Tighten ($\xi < 95\%$) or relax ($\xi = 97.5\%$) max lvg. for intermediary
  - Tighter constraint reduces defaults and macro vol *up to a point*
  - But also shrinks size of the economy (GDP, banking and corp sectors)
  - On net, this macro-prudential policy slightly increases aggregate welfare
  - Intermediary gains the most from bank regulation!

	$\xi = 80\%$	$\xi = 85\%$	$\xi = 90\%$	$\xi = 97.5\%$
	Macro Volatility & Financial fragility			
GDP growth	-6.6%	-8.9%	-2.1%	+5.0%
Investment growth	-14.8%	-11.3%	-5.2%	+8.4%
Consumption growth	-3.4%	-5.0%	-11.7%	-13.0%
Loss rates on corp loans	-28.0%	-24.6%	-11.9%	+7.6%
Intermediation failures	-90.7%	-69.8%	-56.6%	+72.0%
	Size of economy			
Output	-0.9%	-0.6%	-0.2%	+0.1%
Capital stock	-1.7%	-1.5%	-0.5%	+0.6%
Deposits	-28.2%	-20.7%	-10.8%	7.6%
	Welfare			
Aggregate welfare	+0.42%	+0.25%	+0.19%	-0.25%
Value function, B	+1.3%	-0.0%	-0.4%	+0.8%
Value function, I	+25.5%	+23.7%	+13.1%	-9.5%
Value function, S	-1.08%	-0.87%	-0.31%	-0.05%
Credit spread	3.48%	3.24%	2.99%	2.52%

Macro-prudential policy

- Tighten ($\xi < 95\%$) or relax ($\xi = 97.5\%$) max lvg. for intermediary
  - Tighter constraint reduces defaults and macro vol *up to a point*
  - But also shrinks size of the economy (GDP, banking and corp sectors)
  - On net, this macro-prudential policy slightly increases aggregate welfare
  - Intermediary gains the most from bank regulation!

	$\xi = 80\%$	$\xi = 85\%$	$\xi = 90\%$	$\xi = 97.5\%$
	Macro Volatility & Financial fragility			
GDP growth	-6.6%	-8.9%	-2.1%	+5.0%
Investment growth	-14.8%	-11.3%	-5.2%	+8.4%
Consumption growth	-3.4%	-5.0%	-11.7%	-13.0%
Loss rates on corp loans	-28.0%	-24.6%	-11.9%	+7.6%
Intermediation failures	-90.7%	-69.8%	-56.6%	+72.0%
	Size of economy			
Output	-0.9%	-0.6%	-0.2%	+0.1%
Capital stock	-1.7%	-1.5%	-0.5%	+0.6%
Deposits	-28.2%	-20.7%	-10.8%	7.6%
	Welfare			
Aggregate welfare	+0.42%	+0.25%	+0.19%	-0.25%
Value function, B	+1.3%	-0.0%	-0.4%	+0.8%
Value function, I	+25.5%	+23.7%	+13.1%	-9.5%
Value function, S	-1.08%	-0.87%	-0.31%	-0.05%
Credit spread	3.48%	3.24%	2.99%	2.52%

Macro-prudential policy

- Tighten ($\xi < 95\%$) or relax ($\xi = 97.5\%$) max lvg. for intermediary
  - Tighter constraint reduces defaults and macro vol *up to a point*
  - But also shrinks size of the economy (GDP, banking and corp sectors)
  - On net, this macro-prudential policy slightly increases aggregate welfare
  - Intermediary gains the most from bank regulation!

	$\xi = 80\%$	$\xi = 85\%$	$\xi = 90\%$	$\xi = 97.5\%$
	Macro Volatility & Financial fragility			
GDP growth	-6.6%	-8.9%	-2.1%	+5.0%
Investment growth	-14.8%	-11.3%	-5.2%	+8.4%
Consumption growth	-3.4%	-5.0%	-11.7%	-13.0%
Loss rates on corp loans	-28.0%	-24.6%	-11.9%	+7.6%
Intermediation failures	-90.7%	-69.8%	-56.6%	+72.0%
	Size of economy			
Output	-0.9%	-0.6%	-0.2%	+0.1%
Capital stock	-1.7%	-1.5%	-0.5%	+0.6%
Deposits	-28.2%	-20.7%	-10.8%	7.6%
	Welfare			
Aggregate welfare	+0.42%	+0.25%	+0.19%	-0.25%
Value function, B	+1.3%	-0.0%	-0.4%	+0.8%
Value function, I	+25.5%	+23.7%	+13.1%	-9.5%
Value function, S	-1.08%	-0.87%	-0.31%	-0.05%
Credit spread	3.48%	3.24%	2.99%	2.52%

Macro-prudential policy

- Tighten ($\xi < 95\%$) or relax ($\xi = 97.5\%$) max lvg. for intermediary
  - Tighter constraint reduces defaults and macro vol *up to a point*
  - But also shrinks size of the economy (GDP, banking and corp sectors)
  - On net, this macro-prudential policy slightly increases aggregate welfare
  - Intermediary gains the most from bank regulation!

	$\xi = 80\%$	$\xi = 85\%$	$\xi = 90\%$	$\xi = 97.5\%$
	Macro Volatility & Financial fragility			
GDP growth	-6.6%	-8.9%	-2.1%	+5.0%
Investment growth	-14.8%	-11.3%	-5.2%	+8.4%
Consumption growth	-3.4%	-5.0%	-11.7%	-13.0%
Loss rates on corp loans	-28.0%	-24.6%	-11.9%	+7.6%
Intermediation failures	-90.7%	-69.8%	-56.6%	+72.0%
	Size of economy			
Output	-0.9%	-0.6%	-0.2%	+0.1%
Capital stock	-1.7%	-1.5%	-0.5%	+0.6%
Deposits	-28.2%	-20.7%	-10.8%	7.6%
	Welfare			
Aggregate welfare	+0.42%	+0.25%	+0.19%	-0.25%
Value function, B	+1.3%	-0.0%	-0.4%	+0.8%
Value function, I	+25.5%	+23.7%	+13.1%	-9.5%
Value function, S	-1.08%	-0.87%	-0.31%	-0.05%
Credit spread	3.48%	3.24%	2.99%	2.52%

Robustness

- Qualitatively and quantitatively, macro prudential results are robust to model variations. Model in which
  - all households have log utility
  - TFP shocks are to the level of productivity (not the growth rate)
  - uncertainty shocks are uncorrelated with TFP shocks
  - bankruptcy costs are not aggregate resource losses

  yields (approximately) the same conclusions

Robustness

- Qualitatively and quantitatively, macro prudential results are robust to model variations. Model in which
  - all households have log utility
  - TFP shocks are to the level of productivity (not the growth rate)
  - uncertainty shocks are uncorrelated with TFP shocks
  - bankruptcy costs are not aggregate resource losses

  yields (approximately) the same conclusions

- In all specifications,
  - intermediaries gain from tighter regulation, while savers lose
  - net effect on borrower welfare depends the strength of financial accelerator effect
  - aggregate welfare depends on preference parameters and weights in utilitarian criterion

Conclusion

- Calibrated macro-economic model with
  - banks who extend long-term defaultable loans to firms
  - and raise deposits from risk averse savers
  - both banks and firms can default
  - and are subject to leverage restrictions
  - endogenous safe asset interest rate
  - rich set of fiscal policy rules, including deposit insurance

Conclusion

- Calibrated macro-economic model with
  - banks who extend long-term defaultable loans to firms
  - and raise deposits from risk averse savers
  - both banks and firms can default
  - and are subject to leverage restrictions
  - endogenous safe asset interest rate
  - rich set of fiscal policy rules, including deposit insurance
- Unconditional macro and asset pricing moments are realistic.

Conclusion

- Calibrated macro-economic model with
  - banks who extend long-term defaultable loans to firms
  - and raise deposits from risk averse savers
  - both banks and firms can default
  - and are subject to leverage restrictions
  - endogenous safe asset interest rate
  - rich set of fiscal policy rules, including deposit insurance
- Unconditional macro and asset pricing moments are realistic.
- Model generates financial crises where GDP and investment fall considerably.

Conclusion

- Calibrated macro-economic model with
  - banks who extend long-term defaultable loans to firms
  - and raise deposits from risk averse savers
  - both banks and firms can default
  - and are subject to leverage restrictions
  - endogenous safe asset interest rate
  - rich set of fiscal policy rules, including deposit insurance
- Unconditional macro and asset pricing moments are realistic.
- Model generates financial crises where GDP and investment fall considerably.
- Use model to evaluate quantitatively effects of macro-prudential policy
  - Intermediary leverage constraint: trade-off between size of economy and consumption vol
  - Large redistributional effects that depend on policy instrument

Borrower-Entrepreneurs: Complete Problem

Back

$$\hat{V}^B(\hat{K}_t^B, \hat{A}_t^B, \mathcal{S}_t^B) = \max_{\{\hat{C}_t^B, \hat{K}_{t+1}^B, m_t, \hat{X}_t, \hat{A}_{t+1}^B, L_t^j\}} \left\{ (1-\beta_B)\left(u_t^B(\hat{C}_t^B, m_t)\right)^{1-1/\nu} + \right.$$

$$\left. + \beta_B \mathsf{E}_t \left[\left(e^{g_{t+1}} \tilde{\hat{V}}^B(e^{-g_{t+1}} \hat{\hat{K}}_{t+1}^B, e^{-g_{t+1}} \hat{\hat{A}}_{t+1}^B, \mathcal{S}_{t+1}^B) \right)^{1-\sigma_B} \right]^{\frac{1-1/\nu}{1-\sigma_B}} \right\}^{\frac{1}{1-1/\nu}}$$

subject to

$$\begin{aligned} \hat{C}_t^B = {} & (1-\tau_\Pi^I) Z_K(\omega_t^*)(\hat{K}_t^B)^{1-\alpha} L_t^\alpha + (1-\tau_t^B)\hat{w}_t^B \bar{L}^B + \hat{G}_t^{T,B} \\ & + p_t[\hat{X}_t + Z_A(\omega_t^*)(1-(1-\tau_\Pi^B)\delta_K)\hat{K}_t^B] \\ & + q_t^m \hat{\hat{A}}_{t+1}^B - Z_A(\omega_t^*)\hat{A}_t^B(1-(1-\theta)\tau_\Pi^B + \delta q_t^m) \\ & - p_t \hat{\hat{K}}_{t+1}^B - \hat{X}_t - \Psi(\hat{X}_t, \hat{K}_t^B) - (1-\tau_\Pi^I) Z_A(\omega_t^*) \sum_{j=B,I,S} \hat{w}_t^j L_t^j \end{aligned}$$

$$F\hat{\hat{A}}_{t+1}^B \leq \Phi p_t Z_A(\omega_t^*)\hat{K}_t^B$$

$$\mathcal{S}_{t+1}^B = h(\mathcal{S}_t^B)$$

with utility function

$$u^B(C,m) = C \exp\left[-\eta\mu_\omega \left(\frac{m}{\mu_\omega}\right)^{\frac{1}{1-\phi}} - 0.5\left(\sigma_\omega \left(\frac{m}{\mu_\omega}\right)^{\frac{1}{1-\phi}} \frac{\eta}{1-\phi}\right)^2 \right]$$

Intermediaries: Complete Problem

Back

$$V^R(\tilde{W}_t^I, \tilde{\rho}_t, \mathcal{S}_t^I) = \max_{C_t^I, A_{t+1}^I, B_t^I} \left\{ (1-\beta_I) \left(\frac{C_t^I}{e^{\tilde{\rho}_t}} \right)^{1-1/\nu} \right.$$
$$\left. + \beta_I \mathrm{E}_t \left[\left(e^{g_{t+1}} \tilde{V}^I \left(W_{t+1}^I, \mathcal{S}_{t+1}^I \right) \right)^{1-\sigma_I} \right]^{\frac{1-1/\nu}{1-\sigma_I}} \right\}^{\frac{1}{1-1/\nu}}$$

subject to:

$$\begin{aligned} C_t^I &= (1-\tau^I) w_t^I \bar{L}^I + \tilde{W}_t^I + G_t^{T,I} \\ &\quad - q_t^m A_{t+1}^I - (q_t^f + \tau_I^{\Pi} r_t^f - \kappa I_{\{B_t^I < 0\}}) B_t^I \\ W_{t+1}^I &= e^{-g_{t+1}} \left[\left(\tilde{M}_{t+1} + Z_A(\omega_{t+1}^*) \delta q_{t+1}^m \right) A_{t+1}^I + B_t^I \right] \\ B_t^I &\geq -\xi q_t^m A_{t+1}^I \\ A_{t+1}^I &\geq 0 \\ \mathcal{S}_{t+1}^I &= h(\mathcal{S}_t^I) \end{aligned}$$

with continuation value

$$\tilde{V}^I(W_t^I, \mathcal{S}_t^I) = \max_{D(\rho)} \mathrm{E}_\rho \left[D(\rho) V^I(0, \rho, \mathcal{S}_t^I) + (1 - D(\rho)) V^I(W_t^I, 0, \mathcal{S}_t^I) \right]$$