A Quantitative Analysis of the Countercyclical Capital Buffer

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The views expressed in this presentation are those of the author do not reflect the positions of the Federal Reserve Bank of St. Louis or the Federal Reserve System.

The Countercyclical Capital Buffer

- Modern macroprudential regulation based on (i) capital and (ii) liquidity regulation
- **Basel II**: pre-2008 capital regulation

$$\text{Bank Capital}_t \geq \kappa \times \text{Bank Assets}_t$$

- **Basel III**: introduces the Countercyclical Capital Buffer (CCyB)

$$\text{Bank Capital}_t \geq \kappa(\mathbb{S}_t) \times \text{Bank Assets}_t$$

where $\mathbb{S}_t$ is the state of the economy

  - BIS: raise κ during periods of "excess aggregate credit growth"
  - Active in Australia, Germany, HK, Sweden, UK

This paper:

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Approach and Results

1. Nonlinear model of endogenous financial crises
    - Economy endogenously enters and exits crisis regions
    - Crises trigger "aggregate demand" recessions
    - Scope for macroprudential regulation
    - Rich interactions between household and bank balance sheets
2. Quantitative exercise
    - Calibrate model to the US pre-GFC
    - Use Model + Data to estimate shocks under Basel II (no CCyB)
    - Counterfactual: Crisis and Great Recession under Basel III (CCyB)
3. Results
    (a) CCyB: freq. crises $\downarrow$ by 75% (ex-ante), worsens severity ex-post
    (b) Crisis severity can be attenuated with a "CCyB Release" policy
    (c) CCyB prevents crisis in 2008 (but not subsequent recession)
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Relation to the Literature

1. **Basel II**: What is the optimal level of capital requirements?
   Van den Heuvel (2008), Nguyen (2014), Martinez-Miera and Suarez (2014), Begenau (2015), Landvoigt and Begenau (2016)

2. **Basel III**: How should capital requirements change with the state of the economy?
   Karmakar (2016), Davidyuk (2017), Elenev, Landvoigt, and Van Nieuwerburgh (2018), Mendicino, Nikolov, Suarez, and Supera (2018)

This paper: Quantitative (positive) analysis of current CCyB framework.

- Gertler, Kiyotaki, and Prestipino (2018): bank runs in a DSGE model
- Faria-e-Castro (2022): model of financial crises and policy counterfactuals based on particle filter

Model

Key ingredients:

- Household default
- Frictional intermediation between borrowers, firms, and savers
- Bank runs
- Nominal rigidities

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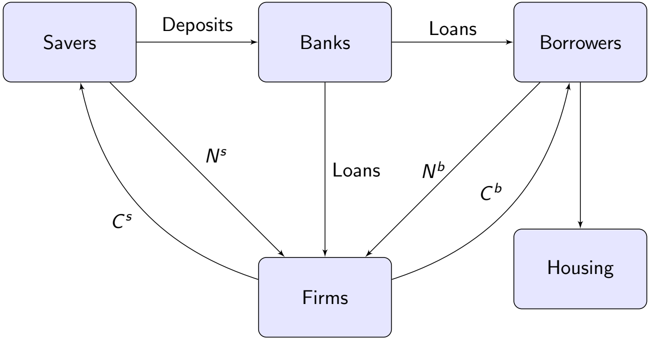

Key Model Ingredient I: Borrowers

Details

- Borrow in long-term debt B_t^b, purchase houses h_t
- Family construct w/ housing quality and moving shocks. In equilibrium:

$$\text{household default}_t = f\left(\frac{B_{t-1}^b/\Pi_t}{p_t^h h_{t-1}}\right)$$

- New borrowing subject to LTV constraint

$$B_t^{b,\text{new}} \leq \theta^{LTV} p_t^h h_t^{\text{new}}$$

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Details

- Banks maximize PDV of dividends subject to capital requirement

$$\underbrace{\kappa_t}_{\text{capital requirement}} \left(\overbrace{Q_t^b B_t^b}^{\text{hh lending}} + \overbrace{Q_t^f B_t^f}^{\text{firm lending}} \right) \leq \underbrace{\Phi_t E_t}_{\text{bank capital}}$$

- Banks default if equity becomes negative,

$$E_t < 0 \Leftrightarrow R_t^b B_{t-1}^b - D_{t-1} < 0$$

- **Liquidation Friction**: assets of failed banks sold at markdown λ^d, paid to depositors

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- **Runs**: possible if bank solvent, but illiquid

$$R_t^b B_{t-1}^b - D_{t-1} \geq 0 \qquad \text{(solvent)}$$
$$(1-\lambda^d) R_t^b B_{t-1}^b - D_{t-1} < 0 \qquad \text{(illiquid)}$$

- Runs self-fulfilling in this region
- Multiplicity solved as in Diamond & Dybvig (1983): sunspot, $\omega_t = 1$ w.p. p
- Crisis and insolvency regions depend on state variables (B_{t-1}, D_t)

$$\text{liquidity threshold} \quad : u_t^R \equiv \frac{D_{t-1}}{(1-\lambda^d) R_t^b B_{t-1}^b}$$

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Run impossible if $u_t^R < 1$. Run possible if $u_t^I < 1 < u_t^R$. Run certain if $u_t^I > 1$.

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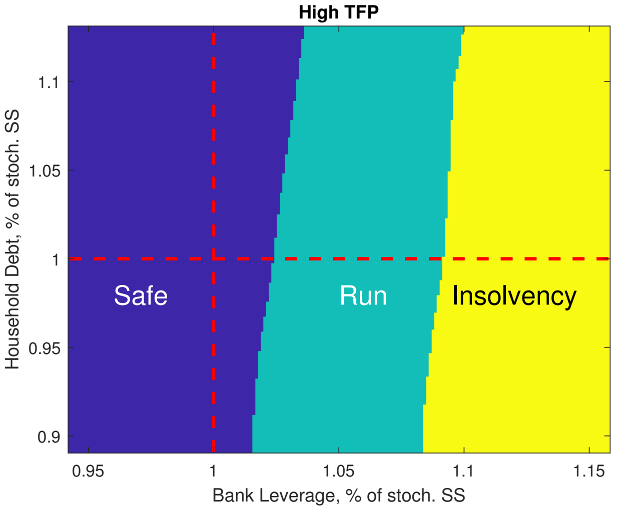
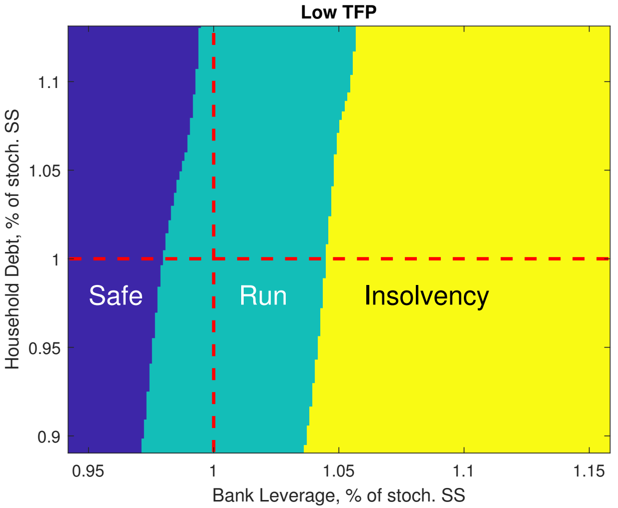


Safe, Run, and Insolvency regions

Run Regions: Low TFP



Safe, Run, and Insolvency regions

Impulse and Propagation

- Aggregate shocks:
  1. TFP A_t
  2. Sunspot shock ω_t
  3. Funding preference shock μ_t
- If bank leverage is high (relative to other states), sunspot may trigger a run
  1. Bank capital collapses: lending $\downarrow$, spreads $\uparrow$
  2. Lending $\downarrow$, spreads $\uparrow$ $\Rightarrow$ disposable income $\downarrow$ $\Rightarrow$consumption $\downarrow$
  3. Borrower constraint starts binding, MPC $\uparrow$
  4. consumption $\downarrow$ $\Rightarrow$ house prices $\downarrow$ (through SDF) $\Rightarrow$ defaults $\uparrow$
  5. Persistent defaults further hamper bank capital
- **Nominal rigidities**: borrower consumption $\downarrow$ $\Rightarrow$ GDP $\downarrow$
  - Working capital constraint: bank capital $\downarrow$ $\Rightarrow$ marginal costs $\uparrow$

Banking Crisis $\Rightarrow$ Demand-driven recession (Mian & Sufi 2014)

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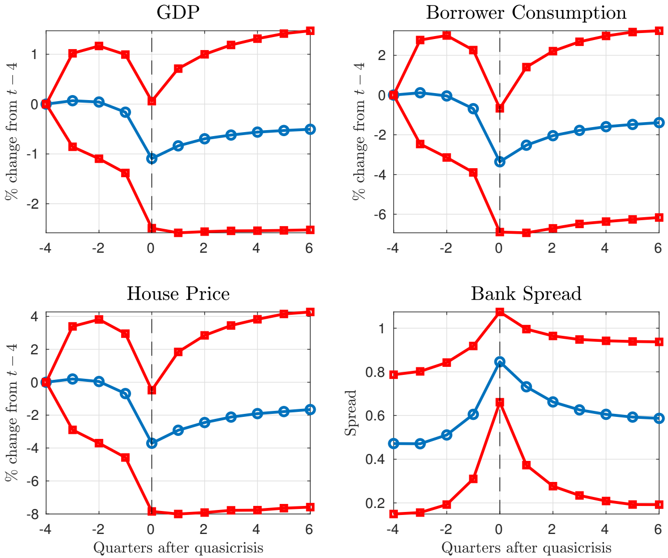
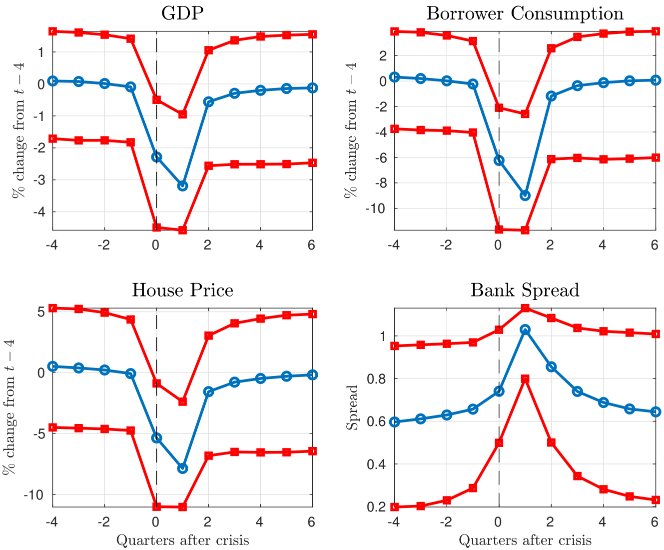
Entering the Crisis Region



Typical Financial Crisis



CCyB Implementation

- Benchmark capital requirement $\bar{\kappa} = 8.5\%$ (MCR + CCB)
- BIS CCyB implementation range: $[0, 2.5\%]$
- Idea: κ_t responds to $u_t^R \simeq$ proxy for bank leverage
- Baseline policy:

$$\kappa_t = \begin{cases} \bar{\kappa} \times \max\{1, u_t^R\}^{\phi_\kappa}, & \text{for } \text{run}_t = 0 \\ \bar{\kappa}, & \text{for } \text{run}_t = 1 \end{cases}$$

- "CCyB Release" policy:

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Effects of Policies

Variable	(i) No Policy	(ii) CCyB Policy	(iii) CCyB Release
Bank Leverage	10.06	8.68	8.67
Pr. of Crisis	5.07	1.29	1.22
Median % Δ GDP in Crisis	-3.02	-3.34	-2.99
CEV Saver		+2.73%	+2.76%
CEV Borrower		-3.14%	-3.18%

- CCyB amplifies precautionary motives for banks
- Lower bank leverage $\Rightarrow$ lower run probability
- CCyB deepens crisis severity $\Rightarrow$ time-consistency problem
- Savers like CCyB; borrowers dislike it

Could CCyB have helped in 2008?

1. Estimate structural shocks $\{A_t, \mu_t, \omega_t\}_{t=0}^T$
   - Make model match observables given $\kappa_t = \bar{\kappa}$ (Basel II)
   - Sample: 2000Q1 - 2015Q4
   - Observables $\{\mathcal{Y}_t\}_{t=0}^T \equiv \{C_t, \text{TED spread}_t\}_{t=0}^T$ Macro Data
   - Use adapted particle filter (Fernández-Villaverde and Rubio-Ramírez, 2007) to estimate

$$\{\hat{p}(A_t, \mu_t, \omega_t | \mathcal{Y}_t)\}_{t=0}^T$$

Particle Filter details

2. Use resulting estimates $\{\hat{A}_t, \hat{\mu}_t, \hat{\omega}_t\}_{t=0}^T$ to study counterfactuals:
   - CCyB
   - CCyB release

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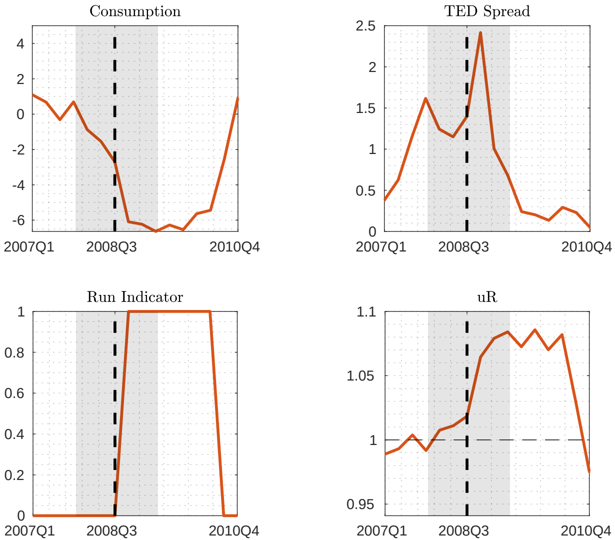
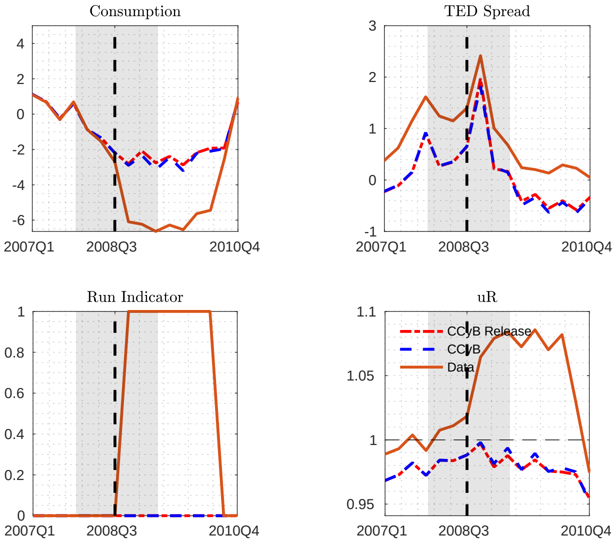
Crisis of 2007-2008, No Policy



Crisis of 2007-2008, CCyB Counterfactual



Summary of Results

- CCyB could have prevented bank run in 2007-08
  - ...but not a (smaller) recession
  - Recession mostly driven by TFP shocks
  - CCyB could have helped with "soft landing"
  - u_t^R remains below 1 $\Rightarrow$ no need to activate CCyB along equilibrium path
- **Quantifying Results**: define the consumption gap

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	$\mathcal{G}$	$\mathcal{G} \times C_{2007Q1}^{\text{data}}$
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This Paper

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- Structural Model + Data

CCyB

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- CCyB release policy could help with time-consistency issues
- Could have mitigated financial panic in 2007-08
- CCyB effective even if not activated
- “Stark rule”: results robust to other types of rules

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Borrowers: Debt and Default

Back

- Face value B^b_{t-1},
- Fraction γ matures every period
- Family construct

1. Borrower family enters period with states

$$h_{t-1}, B^b_{t-1}$$

2. Continuum of members $i \in [0, 1]$, each with

$$h_{t-1}, B^b_{t-1}, \nu_t(i), \zeta_t(i)$$

where

$\nu_t(i) \sim F^b \in [0, \infty)$ is a **house quality shock**

$\zeta_t(i) = 1$ w.p. m is a **moving shock**

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- If $\zeta_t(i) = 1$, w.p. m, has to move. Can either:

1. Prepay remaining balance B^b_{t-1}, and sell house worth $\nu_t(i) p_t h_{t-1}$

or

2. Default on maturing debt, lose collateral

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Borrower Family Problem

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$$V_t^b(B_{t-1}^b, h_{t-1}) = \max_{c_t^b, n_t^b, h_t^{\text{new}}, B_t^{b,\text{new}}, \iota(\nu)} \left\{ u(c_t, n_t) + \xi^b \log(h_t) + \beta \mathbb{E}_t V_{t+1}^b(B_t^b, h_t) \right\}$$

subject to budget constraint

$$c_t^b + \underbrace{\frac{B_{t-1}^b}{\Pi_t} \left\{ (1-\mathrm{m})\gamma + \mathrm{m} \int [1-\iota(\nu)] \mathrm{d}F^b(\nu) \right\}}_{\text{debt repayment}} + \underbrace{p_t h_t^{\text{new}}}_{\text{house purchase}} \leq$$

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and borrowing constraint

$$B_t^{b,\text{new}} \leq \theta^{LTV} p_t h_t^{\text{new}}$$

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- Default iff $\nu \leq \nu_t^*$,

$$\nu_t^* = \frac{B_{t-1}^b}{\Pi_t p_t h_{t-1}} \simeq \text{Loan-to-Value}$$

- Default rate $= F^b(\nu_t^*)$

- Lender payoff per unit of debt

$$R_t^b = \underbrace{(1-\mathrm{m})[(1-\gamma)Q_t^b + \gamma]}_{\text{non-movers}} + \mathrm{m}\left\{\underbrace{1 - F^b(\nu_t^*)}_{\text{repaid}} + \underbrace{\overbrace{(1-\lambda^b)}^{\text{Resource Cost}} \int_0^{\nu_t^*} \nu \frac{p_t h_{t-1}}{B_{t-1}^b / \Pi_t} \mathrm{d}F^b}_{\text{foreclosed}}\right\}$$

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Banks

▸ Back

- Continuum of banks indexed by i
- Choose household lending b^b, firm lending b^f, deposits d, dividends θ
- State variable: capital e
- Run taken as given

$$\underbrace{V_{it}(e_{it})}_{\text{mkt value}} = \max_{b^b_{it+1}, b^f_{it+1}, d_{it+1}, \theta_{it}} \underbrace{(1-\theta_{it})e_{it}}_{\text{dividend}} - \underbrace{\frac{\varphi}{2} e_{it}(\theta_{it} - \bar{\theta})^2}_{\text{div adj costs}} + \underbrace{\mathbb{E}_t \left\{ \Lambda^s_{t,t+1} \max\{0, V_{it+1}(e_{it+1})\} \right\}}_{\text{ex-dividend value}}$$

s.t.

$$\begin{aligned}
\text{budget constraint:} \quad & Q^b_t b^b_{it+1} + Q^f_t b^f_{it+1} = \theta_{it} e_{it} + Q^d_t d_{it+1} + b^f_{it+1} \\
\text{capital req.:} \quad & V_{it}(e_{it}) \geq \kappa_t (Q^b_t b^b_{it+1} + Q^f_t b^f_{it+1}) \\
\text{LoM equity:} \quad & e_{it+1} = \frac{(1 - \text{run}_{t+1})}{\Pi_{t+1}} [R^b_{t+1} b^b_{it+1} - d_{it+1}]
\end{aligned}$$

Bank problem linear in e_{it} $\Rightarrow$ **aggregation**

Bank Problem: Asset Pricing

Back

First-order condition with respect to lending:

$$\mathbb{E}_t \left[\frac{\Lambda_{t+1}}{\Pi_{t+1}} \underbrace{(1 - x_{t+1})}_{\text{future runs}} \underbrace{\Phi_{t+1}}_{\text{future constraints}} \left(\frac{\overbrace{R^b_{t+1}}^{\text{credit risk}}}{Q^b_t} - \frac{1}{Q^d_t} \right) \right] = \underbrace{\kappa_t \mu_t}_{\text{current constraints}}$$

where Φ_t is such that $V_t(e_t) = \Phi_t e_t$ and

$$\Phi_t = \frac{\left\{ 1 + \bar{\theta} \left[(Q^d_t)^{-1} \mathbb{E}_t \Omega_{t+1} - 1 \right] + \frac{1}{2\varphi} \left[(Q^d_t)^{-1} \mathbb{E}_t \Omega_{t+1} - 1 \right]^2 \right\}}{1 - \mu_t}$$

$$\Omega_{t+1} = \frac{\Lambda_{t,t+1}}{\Pi_{t+1}} (1 - x_{t+1}) \Phi_{t+1}$$

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Closing the Model

Back

Standard DSGE model w/ nominal rigidities

- Producers w/ Working Capital constraint → Phillips Curve producers
- Savers → Standard Euler Equation, Funding Shock μ_t savers
- Housing in fixed supply,

$$h_t = 1$$

- Central Bank → Taylor Rule

$$\frac{1}{Q_t} = \frac{1}{\bar{Q}} \left[\frac{\Pi_t}{\Pi}\right]^{\phi_\pi} \left[\frac{Y_t}{Y}\right]^{\phi_y}$$

- Aggregate resource constraint,

$$C_t + \bar{G} + \text{DWL Default}_t = \underbrace{A_t N_t}_{=Y_t} \underbrace{[1 - d(\Pi_t)]}_{\text{Menu Costs}}$$

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Producers

Back

- Hire labor and borrow to produce varieties $i \in [0,1]$

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\varepsilon}{\varepsilon-1}} \mathrm{d}i\right]^{\frac{\varepsilon-1}{\varepsilon}}$$

- Owned by savers with SDF $\Lambda^s_{t,t+1}$
- Subject to working capital constraint

$$Q^f_t B^f_t \geq \psi w_t N_t$$

- Monopolistically competitive, Rotemberg menu costs

$$\text{Menu Costs}_t(i) = P_t Y_t \frac{\eta}{2}\left(\frac{P_t(i)}{P_{t-1}(i)\Pi} - 1\right)^2$$

Firm FOC + Symmetric Price Setting = Standard Phillips Curve

$$\frac{\Pi_t}{\bar{\Pi}}\left(\frac{\Pi_t}{\bar{\Pi}} - 1\right) = \mathbb{E}_t\left[\Lambda^s_{t,t+1}\frac{Y_{t+1}}{Y_t}\frac{\Pi_{t+1}}{\bar{\Pi}}\left(\frac{\Pi_{t+1}}{\bar{\Pi}} - 1\right)\right] + \frac{\varepsilon}{\eta}\left[\frac{\varepsilon-1}{\varepsilon} - \frac{w_t(1+\psi(1-Q^f_t))}{A_t}\right]$$

Savers

Back

- Invest in bank deposits at rate Q_t^d or government debt at rate Q_t
- Own all banks and firms, receive total profits Γ_t

$$V_t^s(D_{t-1}, B_{t-1}^g) = \max_{c_t^s, n_t^s, B_t^g, D_t} \left\{ u(c_t^s, n_t^s) + \beta \mathbb{E}_t V_{t+1}^s \right\}$$

s.t.

$$c_t^s + Q_t B_t^g + \mu_t Q_t^d D_t \leq (1-\tau) w_t n_t^s + \frac{R_t^{\text{deposits}} D_{t-1} + B_{t-1}^g}{\Pi_t} + \Gamma_t - T_t$$

- Γ_t = net transfers from corporate and financial sectors

Back

Calibration

TFP Shock | Funding Shock | back

Moment	Target	Parameter
Households		
Fraction Borrowers	Agg. MPC (Parker et al., 2013)	$\chi = 0.475$
Avg. Maturity	5 years	$\gamma = 1/20$
Max LTV Ratio	85%	$\underline{m} = 0.1160$
Debt/GDP	80%	$\xi = 0.1038$
Avg. Delinquency Rate	2%	$\sigma^b = 4.351$
Banks		
Net Payout Ratio	3.5% (Baron, 2020)	$\bar{theta} = 0.9242$
Capital Requirement	8.5%, Basel III MCR+CCB	$\kappa = 0.085$
Avg. Lending Spread	2%	$\varpi = 0.005$
Avg. TED Spread	0.2%	$\lambda^d = 0.123$
Prob. of Financial Crises	5.0%	$p = 0.05$
Corporate debt/GDP	50%	$\psi = 0.6$

- Two occasionally binding constraints + large crises $\Rightarrow$ global solution Solution Method

Calibration - Standard NK Parameters

back

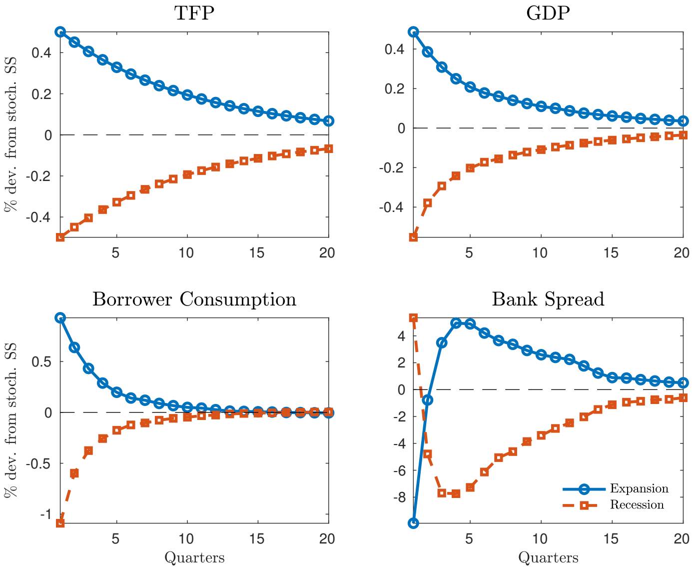
Parameter	Description	Value	Target/Reason
β	Discount Factor	0.995	2% Real Rate
σ	Risk Aversion/EIS	1	Standard
φ	Frisch Elasticity	0.5	Standard
ε	CES	6	20% markup
η	Menu Cost	98.06	$\sim$ Calvo $=$ 0.80
Π	Steady state Inflation	2% annual	U.S.
ϕ_Π	Taylor Rule Inflation	1.5	Standard
ϕ_Y	Taylor Rule GDP	0.5/4	Standard
λ^b	Loss given default	0.3	FDIC estimates

Model Solution ▸ back

- Two occasionally binding constraints $\Rightarrow$ high-order approximation methods not useful
- Aggregate shocks $\Rightarrow$ perfect foresight methods not useful
- Collocation + Time Iteration (Judd, Kubler, and Schmedders, 2002)
  1. Discretize grid of states $(B^b_{t-1}, D_{t-1}, A_t, \mu_t, \omega_t)$
  2. Guess approximants for policy fcns. to evaluate expectations
  3. Solve for current policy fcns. at each gridpoint
  4. Update approximants using solution for current policies
- "Iterates backwards in time" until policies converge
- Challenging due to lack of well-established convergence results
- Garcia and Zangwill (1981) method to handle inequalities

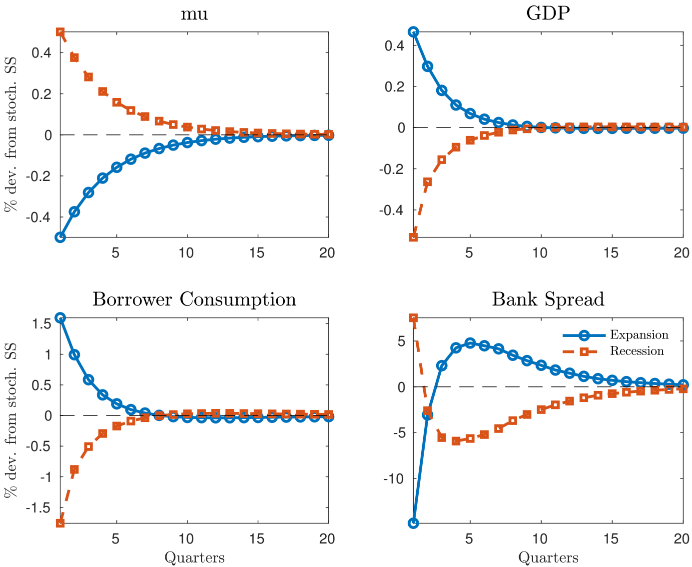
TFP Shock

Back



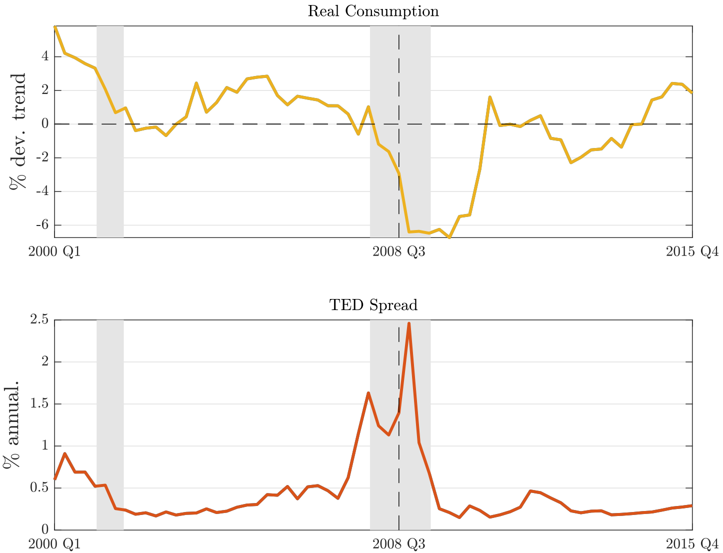
Funding Shock

Back



Data

back



Real Consumption
% dev. trend
4
2
0
-2
-4
-6
2000 Q1
2008 Q3
2015 Q4
TED Spread
% annual.
2.5
2
1.5
1
0.5
0
2000 Q1
2008 Q3
2015 Q4

Particle Filter Algorithm

back

Model in state space form (w./ additive Gaussian measurement error)

$$X_t = f(X_{t-1}, \epsilon_t)$$
$$Y_t = g(X_t) + \eta_t$$
$$\eta_t \sim \mathcal{N}(0, \Sigma)$$

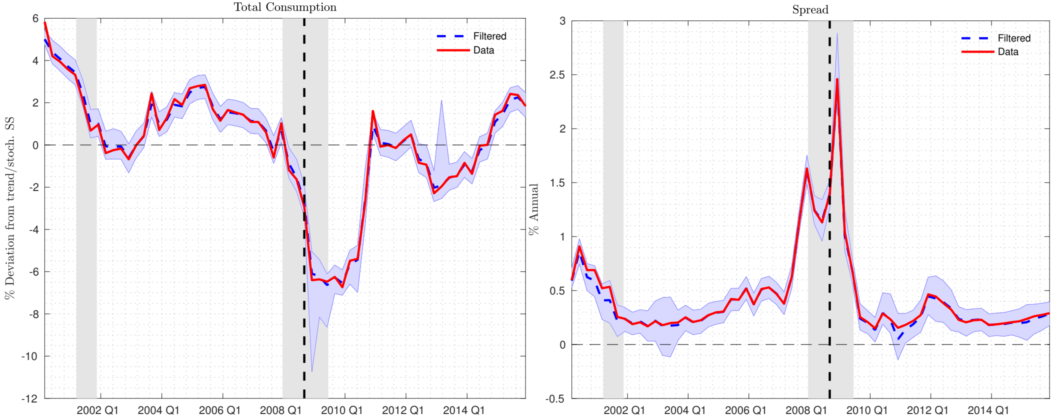
Particle filter output: $\left\{p(X_t|Y^t)\right\}_{t=0}^{T}$

1. Initialize $\{x_0^i\}_{i=1}^N$ by drawing uniformly from the model's ergodic distribution
2. **Adapting**: find $\bar{\epsilon}_t$ that maximizes the likelihood of observing y_t given $\bar{x}_{t-1} \equiv N^{-1}\sum_{i=1}^N x_{t-1}^i$
3. **Prediction**: for each particle i, draw $\epsilon_t^i \sim \mathcal{N}(\bar{\epsilon}_t, I)$ and compute $x_{t|t-1}^i = f(x_{t-1}^i, \epsilon_t^i)$
4. **Filtering**: for each $x_{t|t-1}^i$, compute weight

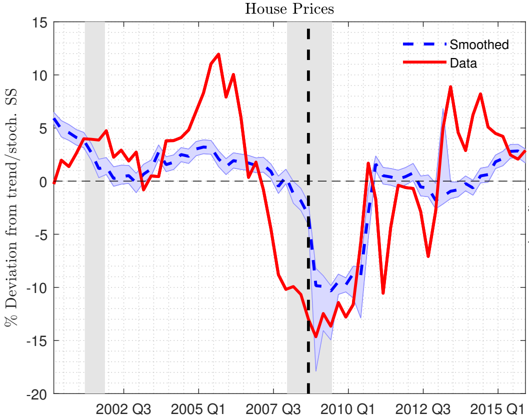
$$\pi_t^i = \frac{p(y_t|x_{t|t-1}^i;\gamma)p(x_t|x_{t|t-1}^i;\gamma)}{h(x_t|y^t, x_{t-1}^i)}$$

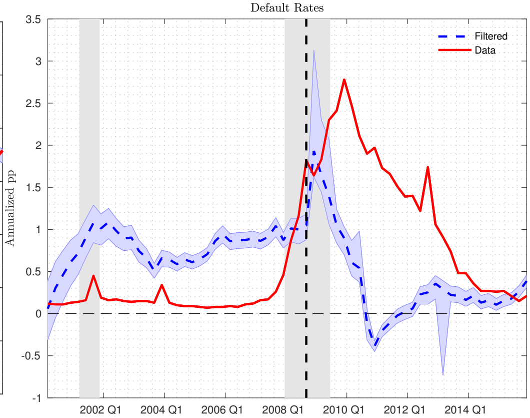
5. **Sampling**: use weights to draw N particles with replacement from $\{x_{t|t-1}^i\}_{i=1}^N$, call them $\{x_t^i\}_{i=1}^N$

Observables: Consumption and TED Spread



Other variables: House Prices, Default Rate





Estimated Shocks