A Quantitative Analysis of the Countercyclical Capital Buffer

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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:

1. What are the quantitative effects of the CCyB?
2. Could the CCyB have prevented a 2008-like crisis in the US?

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)
   (d) Intervention may not be needed in equilibrium

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)

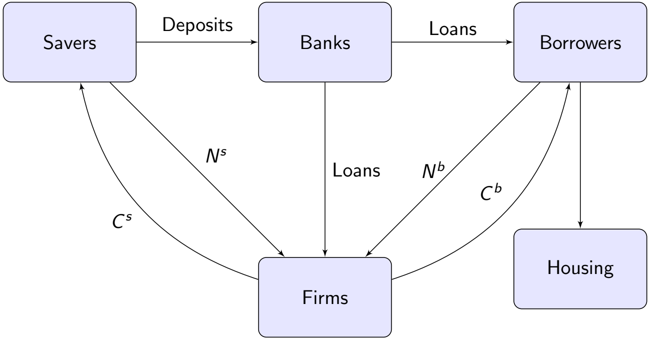
This paper: Quantitative (positive) analysis of current CCyB framework.

- 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



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

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

Key Model Ingredient II: Frictional Banks

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

Key Model Ingredient III: Bank Runs

Details

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

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

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

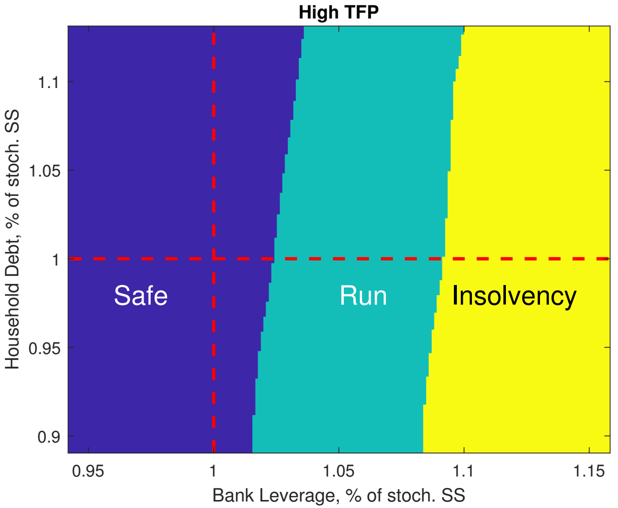
- Runs self-fulfilling in this region
- Multiplicity solved as in Diamond & Dybvig (1983): sunspot, $\omega_t = 1$ w.p. p
- Crisis and insolvency regions depend on state variables (B_{t-1}, D_t)

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

$$\text{solvency threshold} \quad : u_t^I \equiv \frac{D_{t-1}}{R_t^b B_{t-1}^b}$$

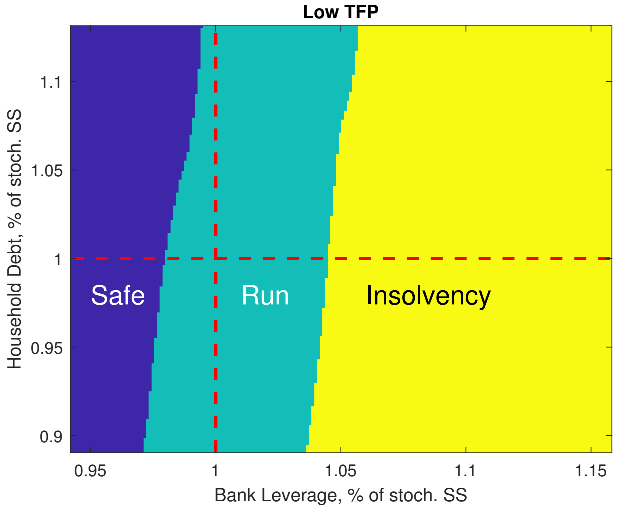
Run impossible if $u_t^R < 1$. Run possible if $u_t^I < 1 < u_t^R$. Run certain if $u_t^I > 1$.

Run Regions: High TFP



Safe, Run, and Insolvency regions

Run Regions: Low TFP



Safe, Run, and Insolvency regions

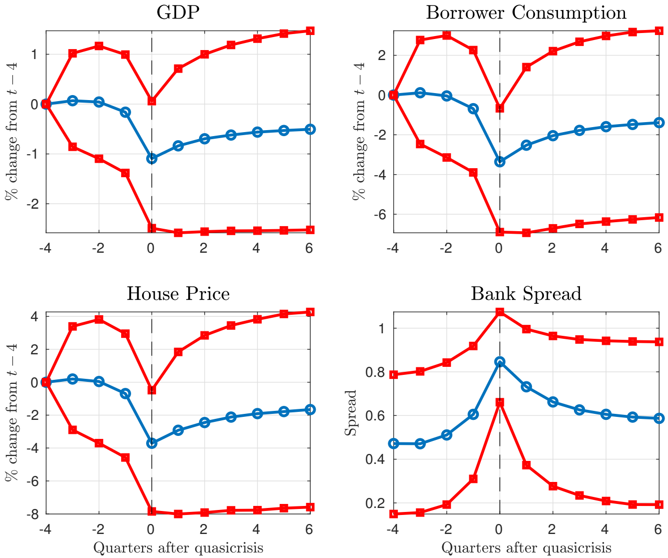
Impulse and Propagation

▸ Closing the Model ▸ Calibration ▸ Solution Method

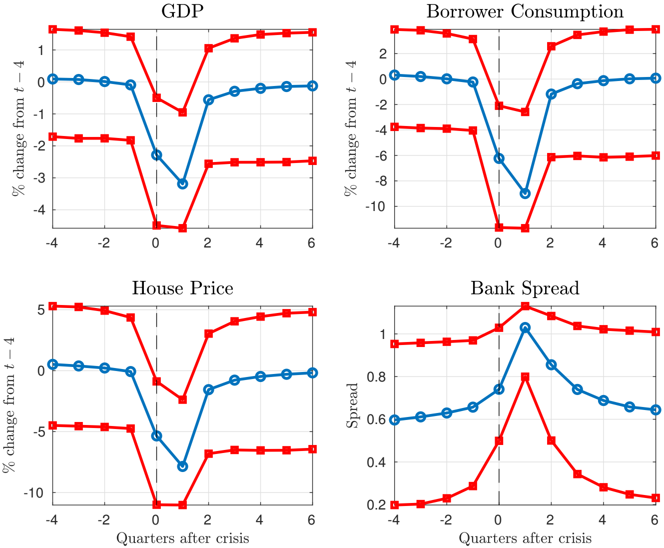
- Aggregate shocks:
    1. TFP A_t
    2. Sunspot shock ω_t
    3. Funding preference shock μ_t
- If bank leverage is high (relative to other states), sunspot may trigger a run
    1. Bank capital collapses: lending $\downarrow$, spreads $\uparrow$
    2. Lending $\downarrow$, spreads $\uparrow$ $\Rightarrow$ 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)

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:

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

- "CCyB Release" policy:

$$\kappa_t = \begin{cases} \bar{\kappa} \times \max\{1, u_t^R\}^{\phi_\kappa}, & \text{for run}_t = 0 \\ \bar{\kappa} - 2.5\%, & \text{for run}_t = 1 \end{cases}$$

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?

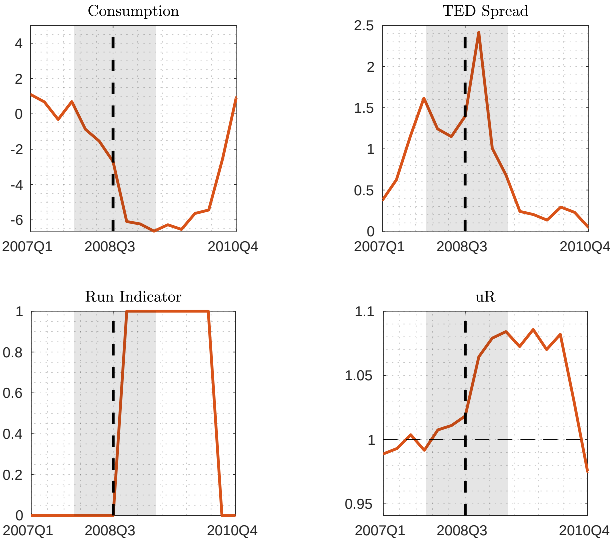
1. Estimate structural shocks $\{A_t, \mu_t, \omega_t\}_{t=0}^{T}$
   - Make model match observables given $\kappa_t = \bar{\kappa}$ (Basel II)
   - Sample: 2000Q1 - 2015Q4
   - Observables $\{\mathcal{Y}_t\}_{t=0}^{T} \equiv \{C_t, \text{TED spread}_t\}_{t=0}^{T}$ ▸ Macro Data
   - Use adapted particle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

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

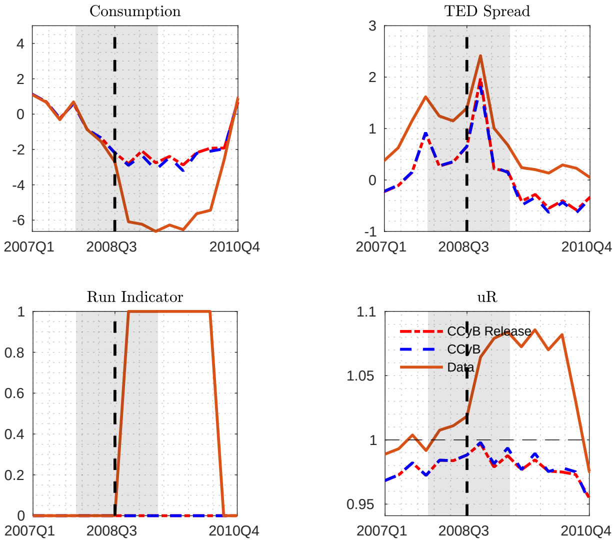
▸ Particle Filter details

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

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

$$\mathcal{G} = \sum_{t=2007Q1}^{T=2010Q4} \frac{C_t^{\text{CCyB}} - C_t^{\text{data}}}{C_{2007Q1}^{\text{data}}}$$

	$\mathcal{G}$	$\mathcal{G} \times C_{2007Q1}^{\text{data}}$
Raise CCyB	25.7%	\$ 2,710.5 bn
Raise+Lower CCyB	26.9%	\$ 2,851.8 bn

Conclusion

This Paper

- Quantitative analysis of CCyB in the 2008-09 financial crisis
- Structural Model + Data

CCyB

- Ex-ante benefits, ex-post costs: likely not time-consistent
- 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

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

$$\nu_t(i) \sim F^b \in [0,\infty) \text{ is a } \textbf{house quality shock}$$
$$\zeta_t(i) = 1 \text{ w.p. } \mathrm{m} \text{ is a } \textbf{moving shock}$$

Borrowers: Debt and Default

Back

- If $\zeta_t(i) = 0$, w.p. $1 - \mathrm{m}$, keeps house, pays coupon γB^b_{t-1}
- 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 $\nu_t(i) p_t h_{t-1}$

     <u>or</u>

  2. Default on maturing debt, lose collateral

Borrower Family Problem

Back

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

subject to budget constraint

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

$$(1-\tau)w_t n_t^b + \underbrace{Q_t^b B_t^{b,\text{new}}}_{\text{new debt}} + \underbrace{\mathrm{m} p_t h_{t-1} \int \nu[1-\gamma\iota(\nu)]\mathrm{d}F^b(\nu)}_{\text{sale of non-forecl. houses}}$$

and borrowing constraint

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

Borrower Default

Back

- 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

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

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.

$$\text{budget constraint:} \quad Q^b_t b^b_{it+1} + Q^f_t b^f_{it+1} = \theta_{it} e_{it} + Q^d_t d_{it+1} + b^f_{it+1}$$

$$\text{capital req.:} \quad V_{it}(e_{it}) \geq \kappa_t (Q^b_t b^b_{it+1} + Q^f_t b^f_{it+1})$$

$$\text{LoM equity:} \quad e_{it+1} = \frac{(1 - \text{run}_{t+1})}{\Pi_{t+1}} [R^b_{t+1} b^b_{it+1} - d_{it+1}]$$

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

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

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

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,

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

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

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

$$\text{Firm FOC} + \text{Symmetric Price Setting} = \text{Standard Phillips Curve}$$

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

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

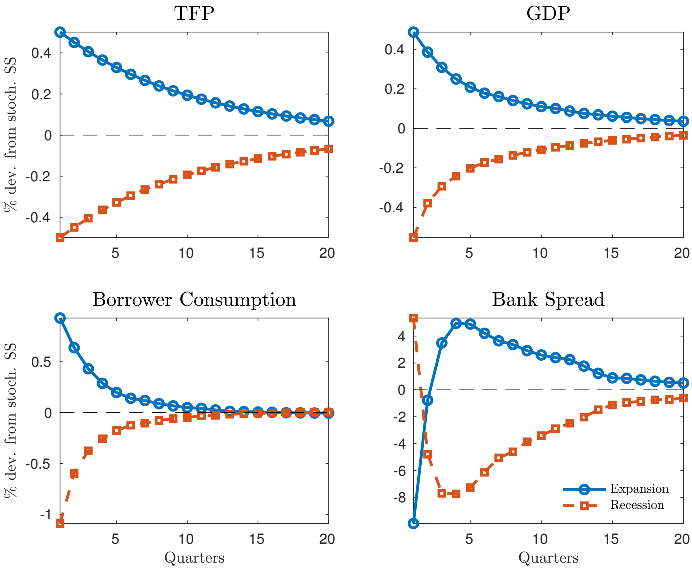
Parameter	Description	Value	Target/Reason
β	Discount Factor	0.995	2% Real Rate
σ	Risk Aversion/EIS	1	Standard
φ	Frisch Elasticity	0.5	Standard
ε	CES	6	20% markup
η	Menu Cost	98.06	$\sim$ Calvo $=$ 0.80
Π	Steady state Inflation	2% annual	U.S.
ϕ_{Π}	Taylor Rule Inflation	1.5	Standard
ϕ_{Y}	Taylor Rule 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

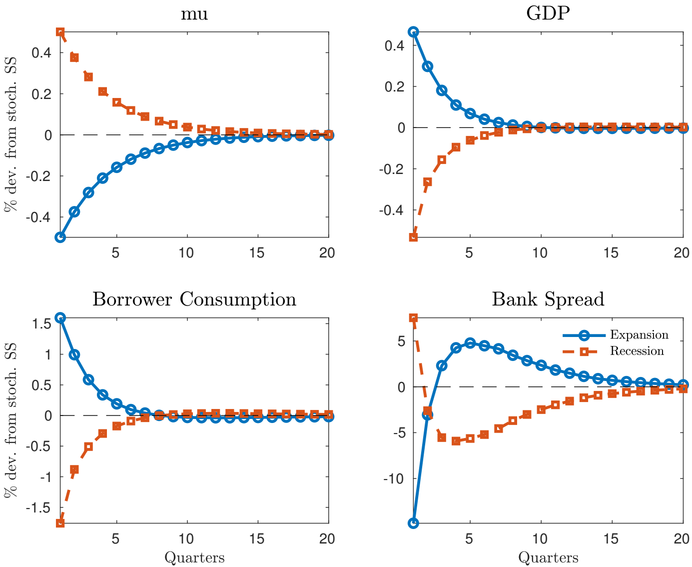
TFP Shock

Back



Funding Shock

Back



Data

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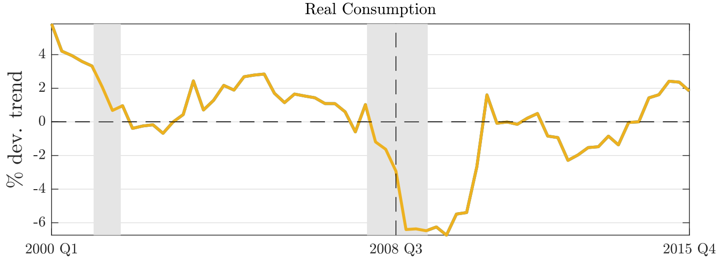
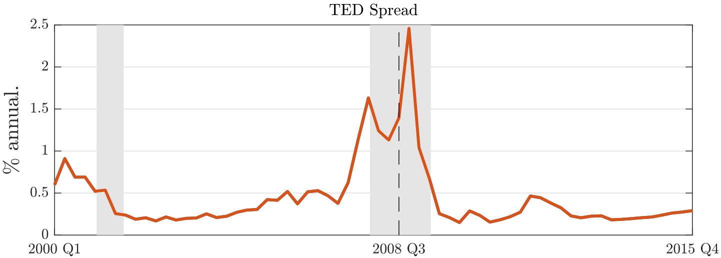


Real Consumption
% dev. trend
4
2
0
-2
-4
-6
2000 Q1
2008 Q3
2015 Q4



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)

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

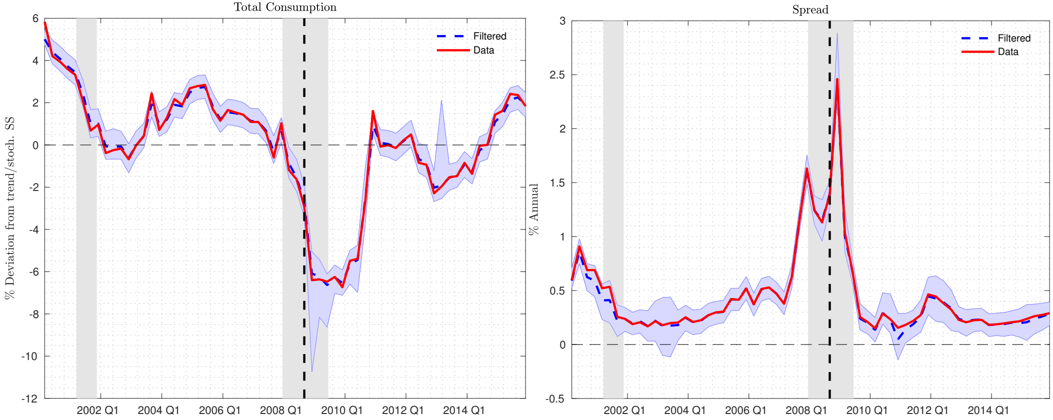
Particle filter output: $\{p(X_t|Y^t)\}_{t=0}^{T}$

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

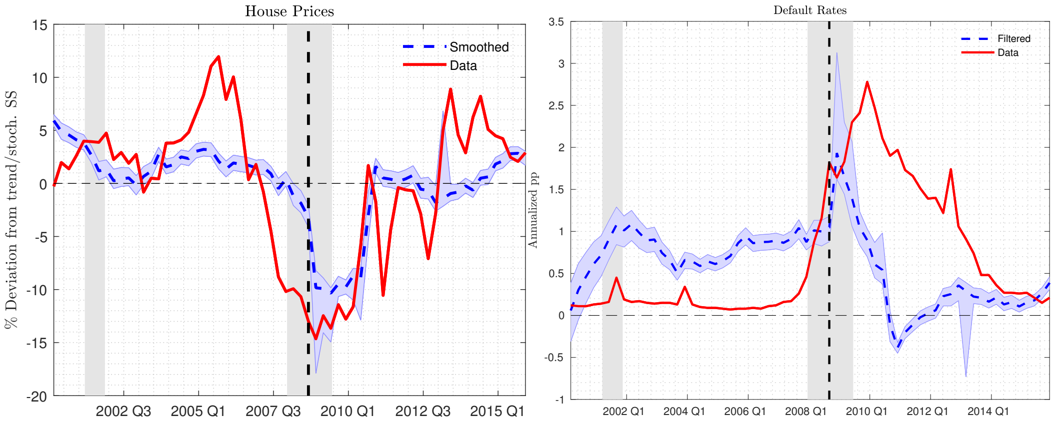
$$\pi_t^i = \frac{p(y_t|x_{t|t-1}^i; \gamma) p(x_t|x_{t|t-1}^i; \gamma)}{h(x_t|y^t, x_{t-1}^i)}$$

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