Fiscal Multipliers and Financial Crises

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Introduction

Fiscal policy response to the 2008 financial crisis

- "Conventional" fiscal stimulus
  1. Govt purchases (Cogan et al. '10; Conley & Dupor '13)
  2. Transfers to households (Oh & Reis '12; Parker et al. '13; Drautzburg & Uhlig '15)
- Financial sector interventions
  3. Equity injections (Blinder & Zandi '10; Philippon & Schnabl '13)
  4. Credit guarantees (Philippon & Skreta '12; Lucas '16)

Large debate on the effectiveness and composition of the response

This paper:

1. How important was the fiscal policy response?
2. Which tools were the most important?

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Approach

1. Structural model of fiscal policy
    - Potential stabilization roles for each of the tools
    - Interactions between household and financial balance sheets
    - State dependent effects of shocks and policies
2. Quantitative exercise
    - Combine calibrated model with data on fiscal response
    - Estimate structural shocks *given* fiscal policy response
    - Study counterfactuals
        - Crisis and Great Recession without fiscal response
        - How do fiscal multipliers evolve over time?

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Results

1. How important was the fiscal policy response?
   $\Rightarrow$ **Aggregate consumption** falls by **twice as much** w/o policy
2. Which tools were the most important?
   $\Rightarrow$ Transfers and Equity Injections

Time series for Fiscal Multipliers

- Govt purchases: relatively low throughout the period
- Transfers and equity injections:

  High/Positive during crisis

  Low/Negative during expansions

State dependence requires

1. Balance sheet interactions
2. Occasionally binding constraints

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Relation to the Literature

1. Fiscal policy response to the Financial Crisis and Great Recession

   Philippon (2010); Coenen et al. (2012); Mian and Sufi (2014); Drautzburg and Uhlig (2015); Blinder and Zandi (2015); Chari and Kehoe (2016)

   - Comprehensive analysis of fiscal policy response in a joint framework
   - Conventional stimulus + financial sector interventions
   - Important to answer normative questions

2. State dependent effects of fiscal policy

   Auerbach and Gorodnichenko (2012); Owyang, Ramey and Zubairy (2013); Canzoneri, Collard, Dellas and Diba (2016); Lucas (2016); Linde and Trabandt (2016)

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Outline of the Talk

1. Model
2. Analysis and Calibration
3. Data and Quantitative Exercise
4. Results and Discussion

Model

Model

Key ingredients

Nominal Rigidities $\Longrightarrow$ Government purchases

Incomplete Markets $\Longrightarrow$ Transfers

Financial Sector Frictions $\Longrightarrow$ Bank Recaps.

Credit Risk & Default $\Longrightarrow$ Credit Guarantees

Environment:

- Time discrete and infinite, $t = 0, 1, \dots$
- Demographics:
  1. Households: borrowers (χ) and savers ($1 - \chi$)
  2. Financial intermediaries
  3. Fiscal authority
  4. Goods producers, central bank
- Incomplete markets: all traded contracts are risky nominal debt

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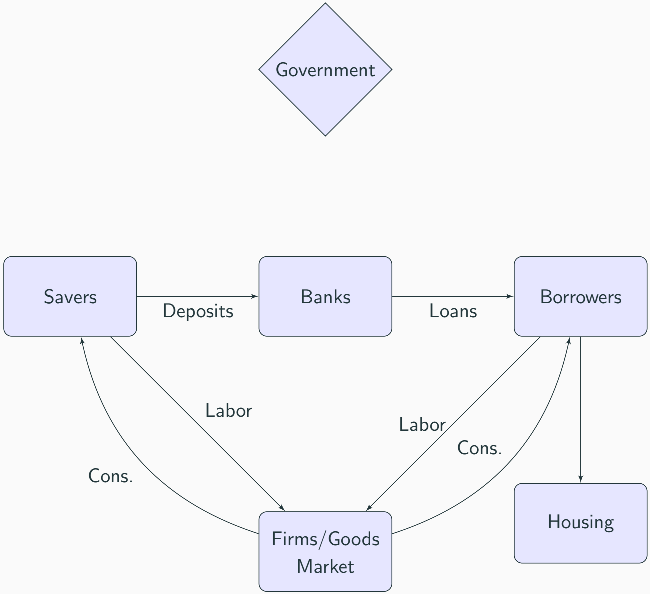
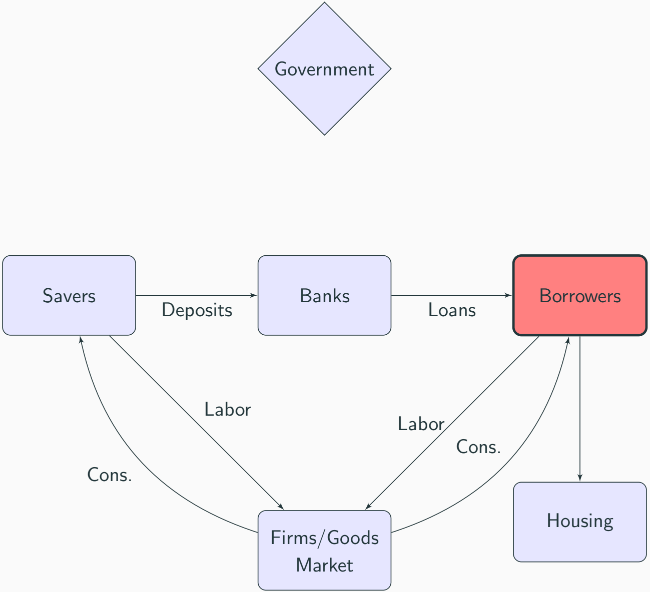
Structure of the Model



Borrowers



Government
Savers
Deposits
Banks
Loans
Borrowers
Labor
Labor
Cons.
Cons.
Housing
Firms/Goods
Market

Borrowers: Debt and Default

- Face value B^b_{t-1},
- Fraction γ matures every period
- Family construct (Landvoigt, 2015)

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

   - $\nu_t(i) \sim F^b_t \in [0, \infty)$ is a **house quality shock**
   - $\zeta_t(i) = 1$ w.p. m is a **moving shock**

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Borrowers: Debt and Default, cont'd

- If $\zeta_t(i) = 0$, member i keeps house, pays coupon γB^b_{t-1}
- If $\zeta_t(i) = 1$, member i 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

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

subject to budget constraint

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

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

and borrowing constraint

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

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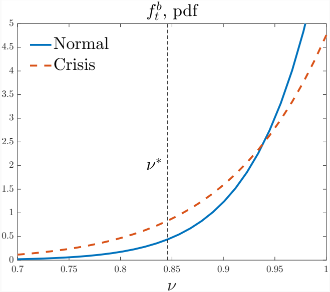
Borrower Default

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

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

- $F_t^b = \text{Beta}(1, \sigma_t^b)$
- $\sigma_t^b \sim$ two-state Markov
- Mean preserving spread



Lenders earn (per unit of debt)

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

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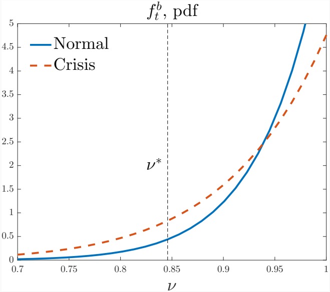

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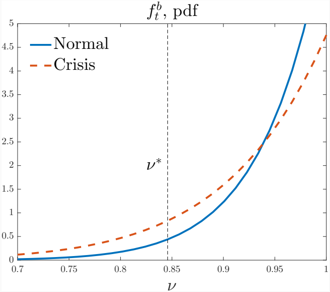

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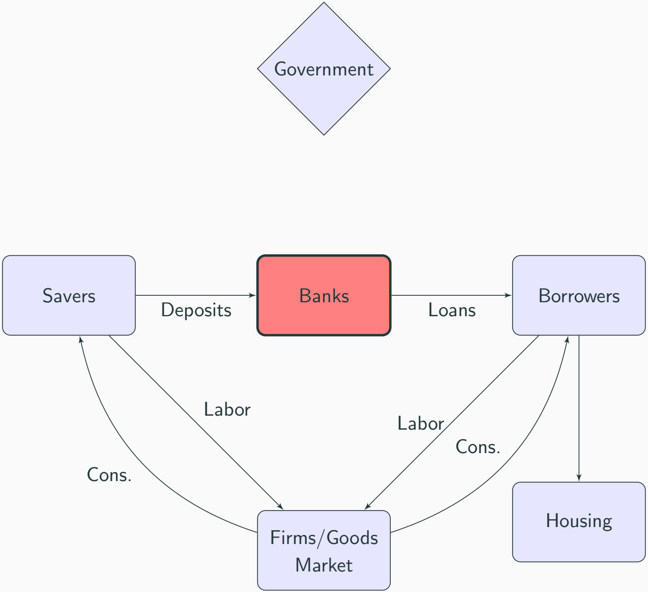

Financial Intermediaries

- Fixed income portfolios, maturity transformation, risky deposits
- Fraction $1-\theta$ of earnings paid out as dividends every period
- Invest in loan securities b_t, raise deposits d_t

Problem for intermediary $j \in [0,1]$ with current earnings $e_{j,t}$

$$\underbrace{V_t^k(e_{j,t})}_{\text{current mkt value}} = \max_{b_{j,t},d_{j,t}} \left\{ \underbrace{(1-\theta)e_{j,t}}_{\text{dividend}} + \underbrace{\mathbb{E}_t\left[\frac{\Lambda^s_{t,t+1}}{\Pi_{t+1}} \max\left\{0, V^k_{t+1}(e_{j,t+1})\right\}\right]}_{\text{ex-dividend value}} \right\}$$

subject to

$$\text{flow of funds}: Q_t^b b_{j,t} = \left[\theta e_{j,t}(1+x_t^k) - \text{Payments to Govt}_t\right] + Q_t^d d_{j,t}$$

$$\text{capital req.}: \kappa Q_t^b b_{j,t} \le \mathbb{E}_t\left[\frac{\Lambda^s_{t,t+1}}{\Pi_{t+1}} \max\left\{0, V^k_{t+1}(e_{j,t+1})\right\}\right]$$

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Problem for intermediary $j \in [0,1]$ with current earnings $e_{j,t}$

$$\underbrace{V_t^k(e_{j,t})}_{\text{current mkt value}} = \max_{b_{j,t},d_{j,t}} \left\{ \underbrace{(1-\theta)e_{j,t}}_{\text{dividend}} + \underbrace{\mathbb{E}_t\left[\frac{\Lambda^s_{t,t+1}}{\Pi_{t+1}} \max\left\{0, V^k_{t+1}(e_{j,t+1})\right\}\right]}_{\text{ex-dividend value}} \right\}$$

subject to

$$\text{flow of funds}: Q_t^b b_{j,t} = \left[\theta e_{j,t}(1+x_t^k) - \text{Payments to Govt}_t\right] + Q_t^d d_{j,t}$$

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$$\text{LoM earnings}: e_{j,t+1} = (u_{j,t+1} Z_{t+1}^{\text{loans}} b_{j,t} - d_{j,t})/\Pi_{t+1}$$

Financial Intermediaries

- Fixed income portfolios, maturity transformation, risky deposits
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- $u_{j,t} \sim F^d \subseteq [\underline{u}, \bar{u}]$
- Default iff

$$u_{j,t} < u_t^* \equiv \frac{d_{j,t-1}}{Z_t^{\text{loans}} b_{j,t-1}} \simeq \text{Leverage}$$

- Aggregation $\Rightarrow$ representative bank
- Payoff per unit of deposits,

$$Z_t^{\text{deposits}} = \underbrace{s_t^d}_{\text{guaranteed}} + (1 - s_t^d) \left\{ \underbrace{1 - F^d(u_t^*)}_{\text{repaid}} + \underbrace{(1 - \lambda^d) \int_0^{u_t^*} u \frac{Z_t^{\text{loans}} B_{t-1}^b}{D_{t-1}} \mathrm{d}F^d}_{\text{liquidated}} \right\}$$

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Closing the Model

Standard DSGE model w/ nominal rigidities

- Producers $\rightarrow$ Phillips Curve ▸ producers
- Savers $\rightarrow$ Euler Equation (IS) ▸ savers
- Housing in fixed supply,

$$h_t = 1$$

- Central Bank $\rightarrow$ 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,

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

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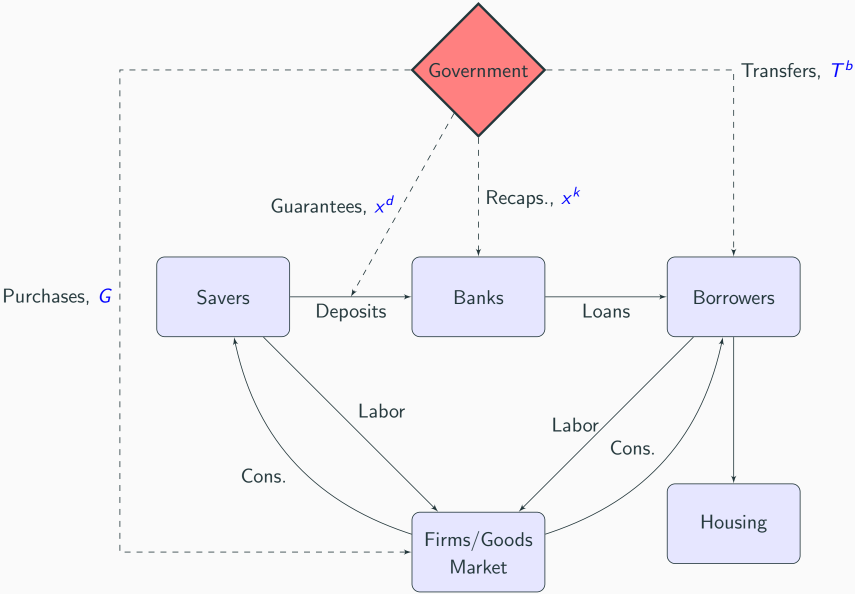
Fiscal Authority



Fiscal Authority

Budget constraint,

$$\underbrace{\tau Y_t + T_t + Q_t B_t^g - \bar{G} - \frac{B_{t-1}^g}{\Pi_t}}_{\text{Standard Surplus}} = \text{Net Cost from Discretionary Measures}_t$$

Fiscal rule for taxes,

$$T_t = \phi_\tau \log\left(\frac{B_{t-1}^g}{\bar{B}^g}\right)$$

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Financial Sector Interventions

Bank Recapitalizations

- Flow x_t^k, stock s_t^k

$$s_t^k = \frac{\theta^k[1 - F^d(u_t^*)]s_{t-1}^k + x_t^k}{1 + x_t^k}$$

$$\text{Net Costs}_t^k = \underbrace{x_t^k E_t}_{\text{Injections}} \underbrace{-(1-\theta^k)s_{t-1}^k \Pi_t^{-1} \int_{u_t^*}^{\bar{u}} u Z_t^b B_{t-1}^b - D_{t-1} \mathrm{d}F^d(u)}_{\text{Repayments}}$$

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Analysis

Model: Impulse and Propagation

- Aggregate shocks:
  1. TFP A_t
  2. Financial shock σ_t

$$\text{Household Default Rate}_t = f(\overset{+}{\text{LTV}}_t, \overset{+}{\sigma}_t)$$

- Financial shock: defaults $\uparrow$
  1. Bank equity $\downarrow$
  2. If bank constraint binds $\Rightarrow$ spreads rise, lending falls
  3. Disposable income for borrowers $\downarrow$
  4. If borrower constraint binds $\Rightarrow$ aggregate consumption $\downarrow$

Shock transmission depends on bank leverage and household leverage

Solution Method

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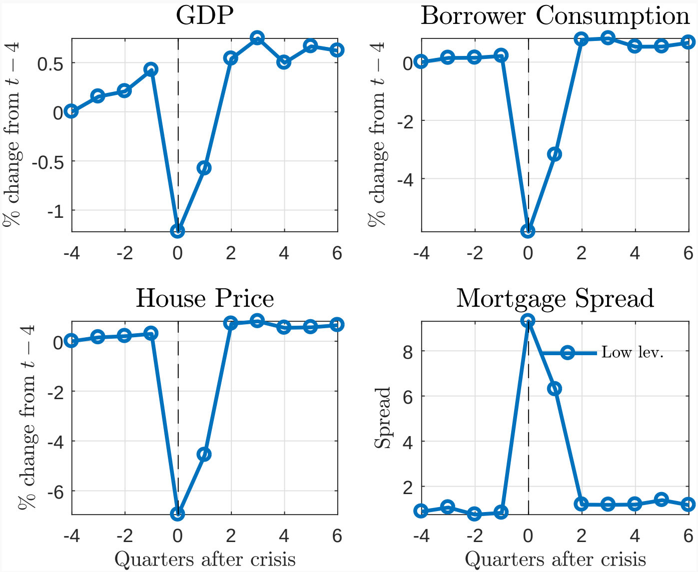
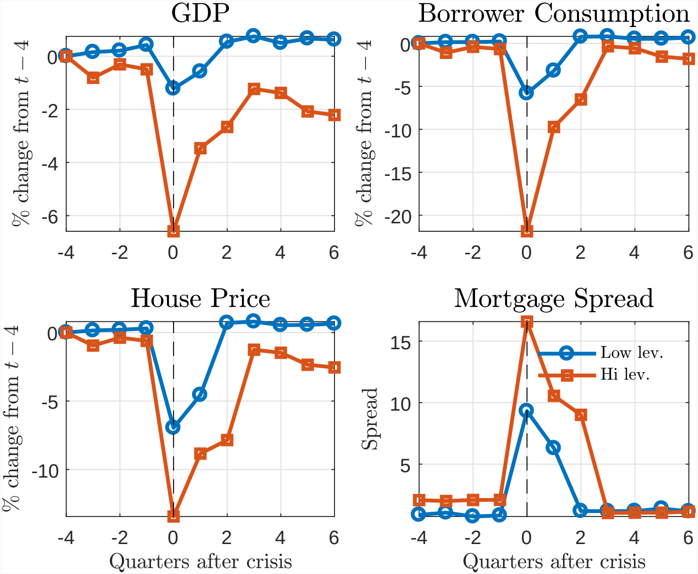
State Dependence: Financial Shock with Low Leverage



State Dependence: Financial Shock with High Leverage



Calibration

1. *Crises*

$$\sigma_t^b = [\sigma_t^{b,\text{normal}}, \sigma_t^{b,\text{crisis}}]^T \qquad \text{and} \qquad \mathbf{P}^\sigma = \begin{bmatrix} .995 & .005 \\ .2 & .8 \end{bmatrix}$$

2. *Households*

Target	Target	Parameter
Fraction Borrowers	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%	$\xi = 0.0899$
Avg. Delinquency Rate	2%	$\sigma^{b,\text{normal}} = 4.351$

3. *Banks*

$$F^d(u) = \frac{u^\sigma - \underline{u}^\sigma}{\bar{u}^\sigma - \underline{u}^\sigma}$$

Target	Target	Parameter
Book Leverage	10	$\kappa = 0.10$
Payout Rate	20%	$\theta = 0.80$
Avg. Lending Spread	2%	$\varpi = 0.068$
Avg. TED Spread	0.2%	$\lambda^d = 0.15$
CDS-Implied Def. Prob.	2% in recessions	$\underline{u} = 0.90, \sigma^d = 1$

Quantitative Exercise

U.S. Fiscal Policy during the Great Recession

Given calibrated model,

1. Collect data on fiscal policy response, $\Omega_t = \{G_t, T_t^b, x_t^k, x_t^d\}$

2. Estimate $\{A_t, \sigma_t^b\}_{t=0}^T$ by making model match data, given $\{\Omega_t\}_{t=0}^T$

$$\text{data}_t = \{C_t, \text{TED Spread}_t\}_{t=2000Q1}^{T=2015Q4}$$

3. Use resulting estimates $\{\hat{A}_t, \hat{\sigma}_t^b\}_{t=2000Q1}^{T=2015Q4}$ to study counterfactuals.

   - Alternative paths for Ω^T

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Fiscal Policy Data

- G_t: ARRA '09 contracts, Medicaid and Education spending
- T_t^b: ESA '08 tax rebates, HERA '08 tax credits + NSP + Cash for Clunkers, ARRA '09 social transfers + tax cuts, TARP '08 housing programs (MHA, HHF, FHA-Refi)
- x_t^k: TARP '08 equity injection programs (CPP, CDCI, PPIP, AIG, BofA/Citi), auto bailout (AIFP, ASSP), GSE bailout (PSI)
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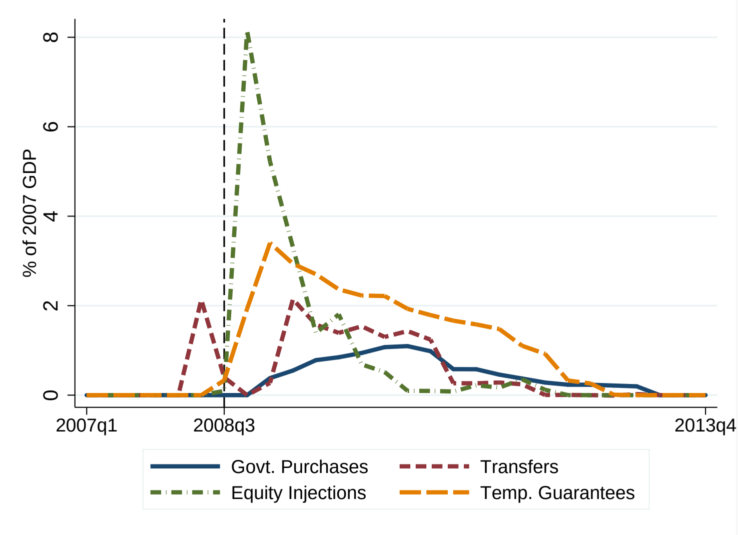

Stochastic Processes for Policies

For $\Omega_t = \{G_t, T_t^b, x_t^k, x_t^d\}$

- Discretionary policies are exogenous shocks
- Each $\omega \in \Omega$ follows two-state process

$$\omega \in [\omega^{\text{SS}}, \omega^{\text{crisis}}]^T$$

with transition

$$\mathbf{P}^\omega = \begin{bmatrix} .995 & .005 \\ 1 - p^\omega & p^\omega \end{bmatrix}$$

- Estimate $(\omega^{\text{crisis}}, p^\omega)$ using maximum likelihood

▸ Discretization

Stochastic Processes for Policies

For $\Omega_t = \{G_t, T_t^b, x_t^k, x_t^d\}$

- Discretionary policies are exogenous shocks
- Each $\omega \in \Omega$ follows two-state process

$$\omega \in [\omega^{\text{SS}}, \omega^{\text{crisis}}]^T$$

with transition

$$\mathbf{P}^\omega = \begin{bmatrix} .995 & .005 \\ 1 - p^\omega & p^\omega \end{bmatrix}$$

- Estimate $(\omega^{\text{crisis}}, p^\omega)$ using maximum likelihood

Discretization

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▸ Discretization

Estimating Shocks

Follow Fernández-Villaverde and Rubio-Ramírez '07

- Fiscal policy shocks $\{\Omega_t\}_{t=0}^T \equiv \{G_t, T_t^b, x_t^k, x_t^d\}_{t=0}^T$
- Observables $\{\mathcal{Y}_t\}_{t=0}^T \equiv \{C_t, \text{TED spread}_t\}_{t=0}^T$ ▸ Macro Data
- Sample: 2000Q1 - 2015Q4

use particle filter to obtain

$$\{\hat{p}(A_t, \sigma_t^b | \mathcal{Y}^T, \Omega^T)\}_{t=0}^T$$

▸ Particle Filter and Smoother

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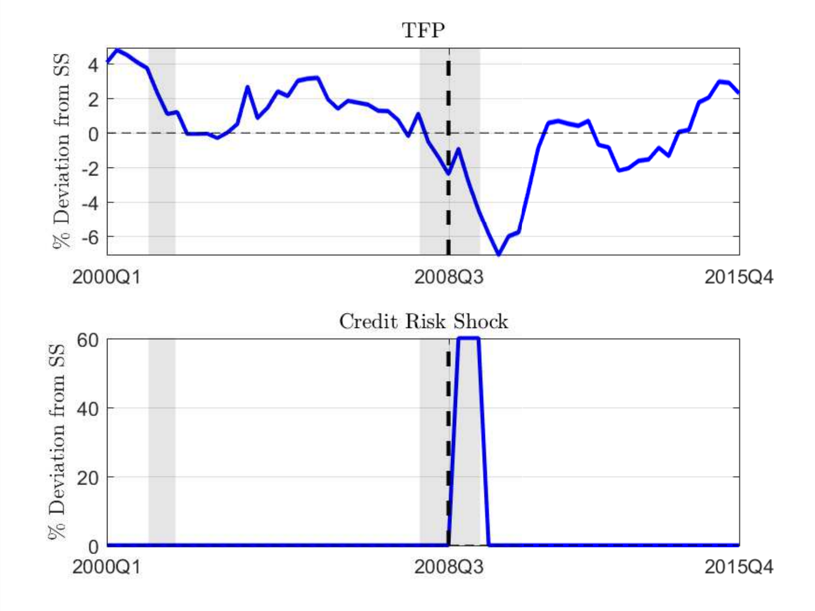
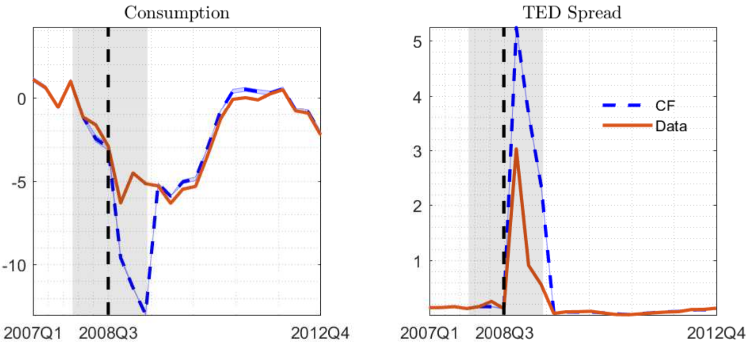
Smoothed Shocks

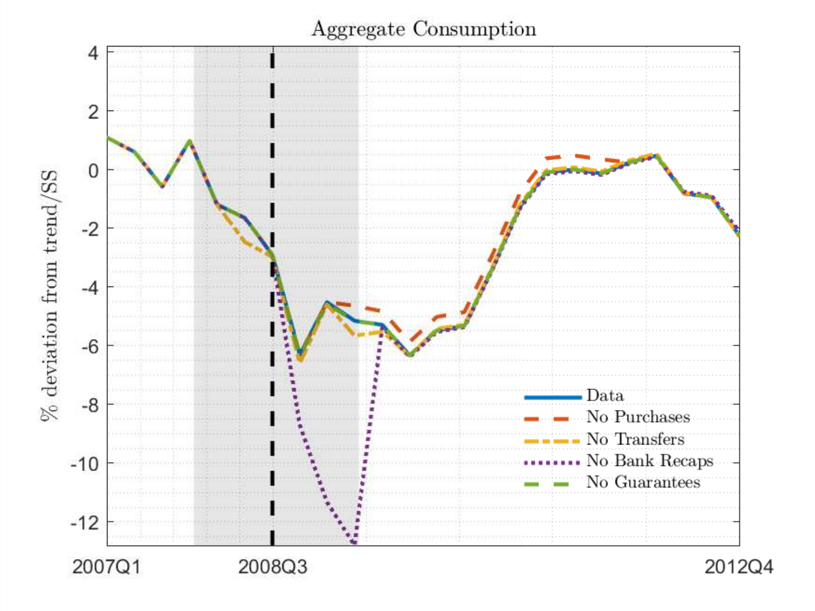


Main Counterfactual: No Fiscal Policy



▸ Other Smoothed Vars.

Policy Decomposition



Fiscal Multipliers

- Estimated sequences of shocks + nonlinear calibrated model

  $\Rightarrow$ Time series for fiscal multipliers

- Long-Run Discounted Multipliers (Mountford & Uhlig '09)

$$\mathcal{M}^{\text{Long-Run}}(\omega) = \frac{\sum_{t=0}^{\infty}\left(\prod_{j=0}^{t} R_j^{-1}\right) \times \left(Y_{t,\text{pol}} - Y_{t,\text{no pol}}\right)}{\sum_{t=0}^{\infty}\left(\prod_{j=0}^{t} R_j^{-1}\right) \times \left(\text{spend}_{t,\text{pol}} - \text{spend}_{t,\text{no pol}}\right)}$$

- Recaps, Guarantees: "Fair-Value Multipliers" (Lucas, '16)

$$\text{spend}_{t,\text{pol}} - \text{spend}_{t,\text{no pol}} = \left(Q^d_{t,\text{pol}} - Q^d_{t,\text{no pol}}\right) \times D_{t,\text{pol}}$$

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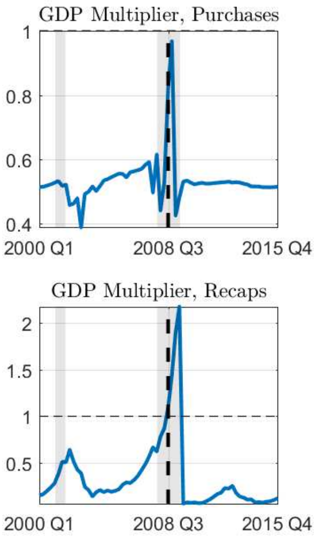
Time Series for Fiscal Multipliers



State Dependent Multipliers: Mechanism

Two channels:

1. Borrower Constraint $\Rightarrow$ conventional MPC channel
2. Borrower Const. + Bank Const. $\Rightarrow$ *new channel*
   - Transfers $\Rightarrow$ house prices $\uparrow$ (only when borrowers are constrained)
   - Default rates fall, banks post fewer losses
   - Lending $\uparrow$, spreads $\downarrow$ (only when banks are constrained)
   - Disposable income $\uparrow$

New channel active when both constraints bind

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- Analysis of fiscal policy response to the Great Recession
- Structural Model + Data

Contribution

- Conventional stimulus and financial sector interventions
  - Important for normative analysis
  - Quantitative evaluation
- New transmission channels for fiscal policy
  - Household-bank balance sheet interactions
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Producers

- 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 $\Lambda^s_{t,t+1}$
- 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

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

Back

Savers

- 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.

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

- Γ_t = net transfers from corporate and financial sectors

Back

Model Solution

- Two occasionally binding constraints, aggregate shocks
- Collocation + Time Iteration (Judd, Kubler, and Schmedders, 2002)
  1. Discretize grid of states $(B^b_{t-1}, D_{t-1}, B^g_{t-1}, A_t, \sigma^b_t)$
  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

back

Calibration - Standard NK Parameters

Parameter	Description	Value	Target/Reason
β	Discount Factor	0.99	3% Real Rate
σ	Risk Aversion/EIS	1	Standard
φ	Frisch Elasticity	1	Standard
ε	CES	6	Mark-up = 20%
η	Menu Cost	58.25	$\sim$ Calvo = 0.80
G	Government Spending	20% of GDP	U.S.
B^g	Government Debt	14% of GDP	U.S. (maturity adjusted)
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
ϕ_τ	Fiscal Rule	0.05	McKay and Reis (2016)
λ^b, λ^d	Losses given default	$0.3, 0.1$	FDIC estimates

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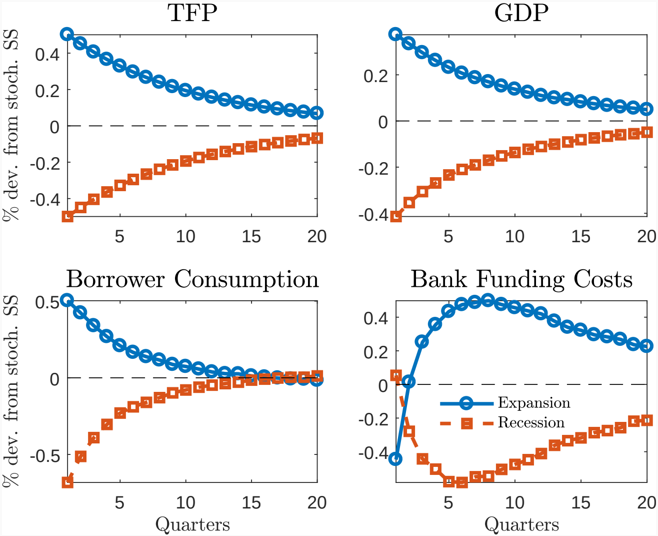
TFP Shock



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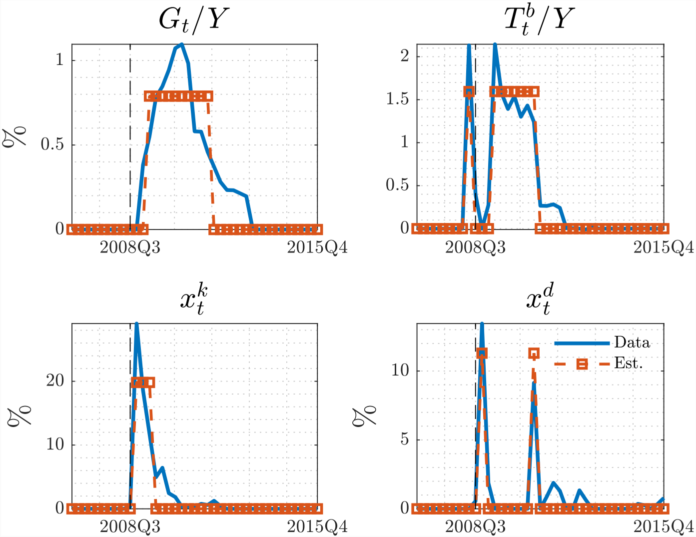
Stochastic Processes for Policies

Maximum likelihood estimation w/. Hamilton filter



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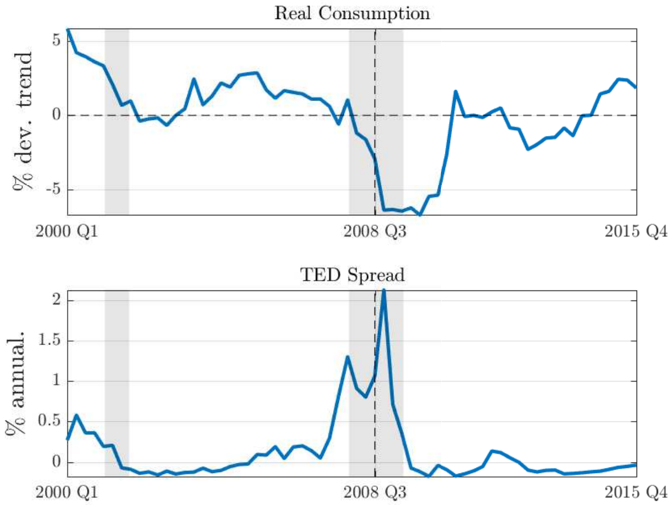
Macroeconomic Data: Consumption and BAA Spread



Particle Smoother Algorithm

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

$$X_t = f(X_{t-1}, \epsilon_t)$$

$$Y_t = g(X_t) + \eta_t$$

$$\eta_t \sim \mathcal{N}(0, \Sigma)$$

Step 1: Run particle filter to obtain

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

1. Initialize $\{x_0^i, \pi_0^i\}_{i=1}^N$ by drawing uniformly from ergodic distr.
2. Prediction: for each particle i, draw ϵ_t^i and compute $x_{t|t-1}^i = f(x_{t-1}^i, \epsilon_t^i)$
3. Filtering: for each $x_{t|t-1}^i$, compute weight

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

4. Sampling: use weights to draw N particles with replacement from

Particle Smoother Algorithm

Step 2: Run smoother to obtain

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

1. Initialize $\{x_T^i, \pi_T^i\}_{i=1}^N$ by drawing uniformly from $\hat{p}(x_T|y^T)$
2. For each i, draw uniformly with replacement $\{x_{t-1|t}^{i,j}\}_{j=1}^M$. Compute an associated weight

$$w_{t-1|t}^{i,j} = \frac{p(\tilde{x}_t^i|x_{t-1|t}^{i,j})}{\sum_{j=1}^M p(\tilde{x}_t^i|x_{t-1|t}^{i,j})}$$

3. Using these weights draw exactly one element from $\{x_{t-1|t}^{i,j}\}_{j=1}^M$, call it x_{t-1}^i. Repeat process for all i.
4. Go backwards, repeating process for all $t < T$.

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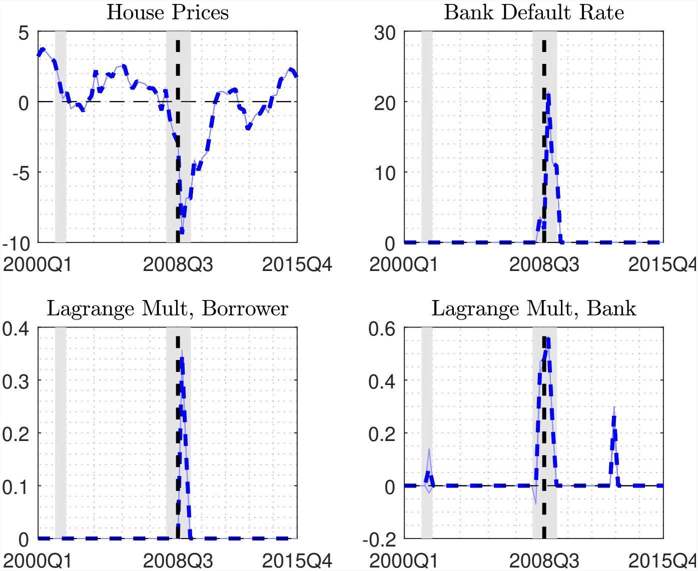
Other Smoothed Series



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