Money Markets, Collateral and Monetary Policy

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Overview

- Interbank money markets: crucial for liquidity management.
- Eurozone crisis from 2010 to 2015. We document
  1. the share of unsecured interbank borrowing declined throughout EMU.
  2. bank borrowing from the ECB increased eight-fold in the South.
  3. market haircuts on Southern government bonds increased substantially.
  4. household deposits at banks remained stable.
- Central bank policy tools: beyond setting interest rates and QE.

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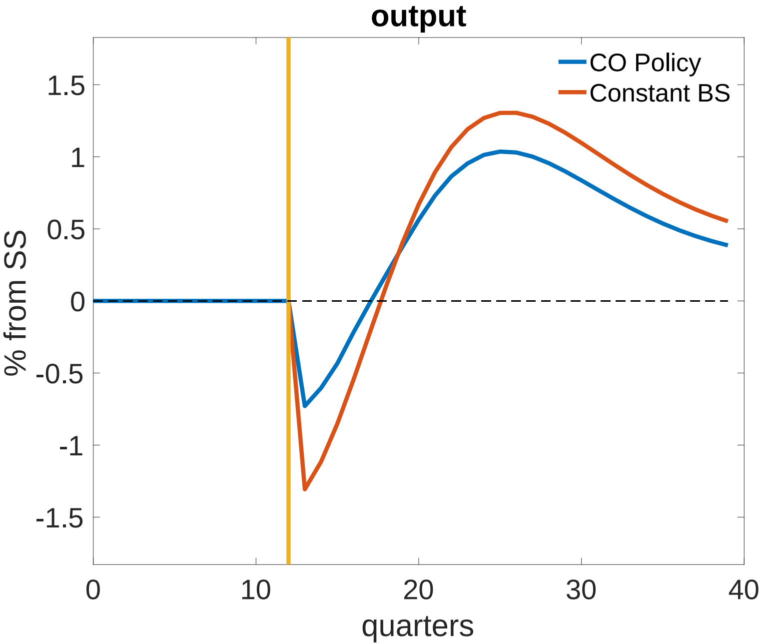
  3. market haircuts on Southern government bonds increased substantially.
  4. household deposits at banks remained stable.
- Central bank policy tools: beyond setting interest rates and QE.
- We construct a quant. GE model to understand these developments.
  - heterogeneous banks, heterogeneous government bonds
  - interbank money markets for both secured and unsecured credit
  - one central bank. May lend against collateral, imposing haircut.
- Compare **B**enchmark to **A**lternative policy:

  B: "collateralized credit operations" **B**enchmark. Haircut at 3 percent.

  A: "constant balance sheet" **A**lternative. Haircut at 100 percent.
- Challenge: five occasionally binding constraints. 91 equations.
- We show
  - the policies differ concerning the rise of private market haircuts.
  - Fall in output would have been twice as high under **A** than **B**.

Impulse Resp.: Benchmark vs Alternative



Literature

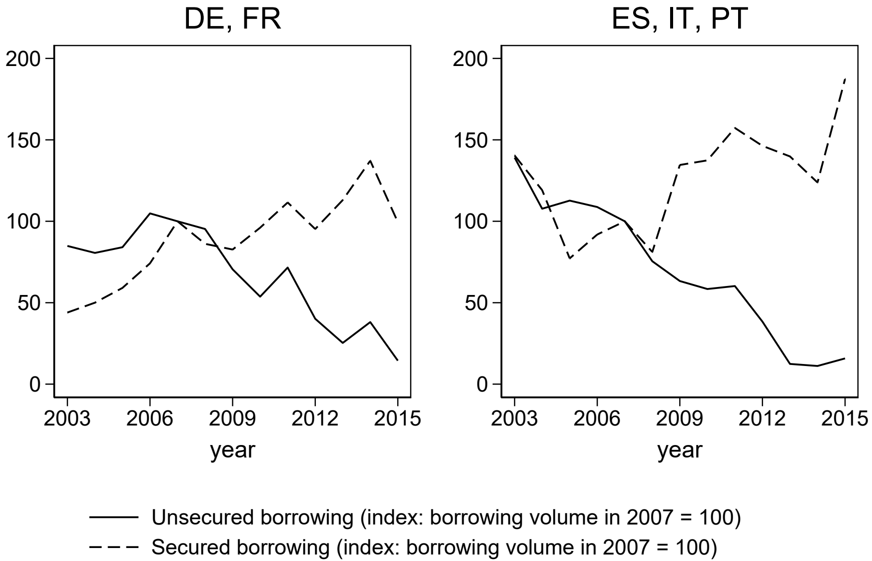
- Bank leverage: Gertler-Karadi (2011), Gertler-Kiyotaki (2011).
- Bank liquidity management: Bianchi-Bigio (2022).

Data

1. Data on haircuts on govmt bonds: LCH.Clearnet website. One of the largest clearers of repo transactions in the euro area. Construct weighted average (see paper).
2. Data on type of borrowing: ECB Money Market Survey. More than 100 participating banks. Proprietary country-level detail. Novel.
3. Bank assets and liabilities: ECB's Statistical Data Warehouse (SDW).

"North": Germany, France.
"South": Italy, Spain, Portugal.

Observation 1: Decline in unsecured share



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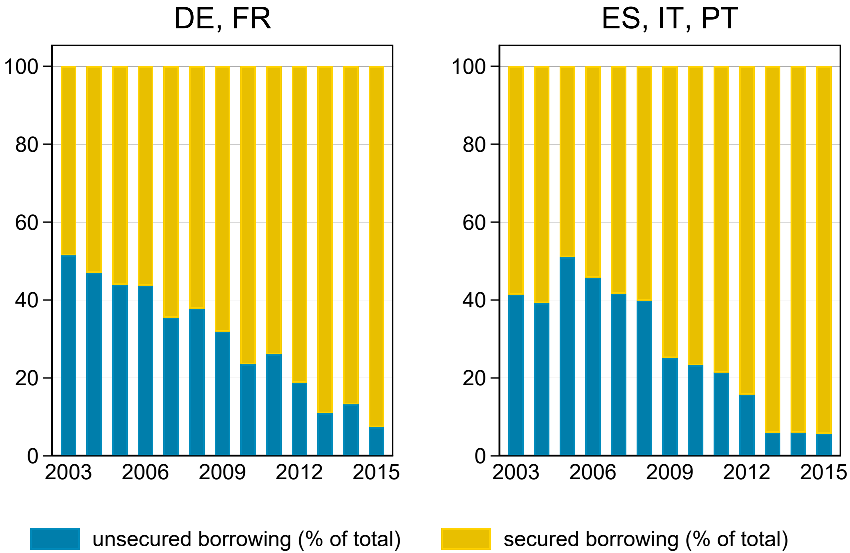
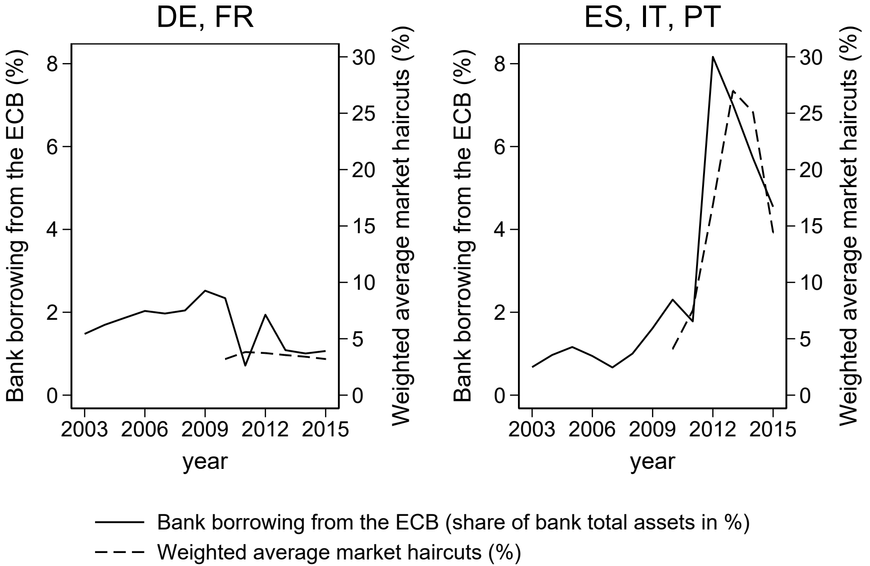
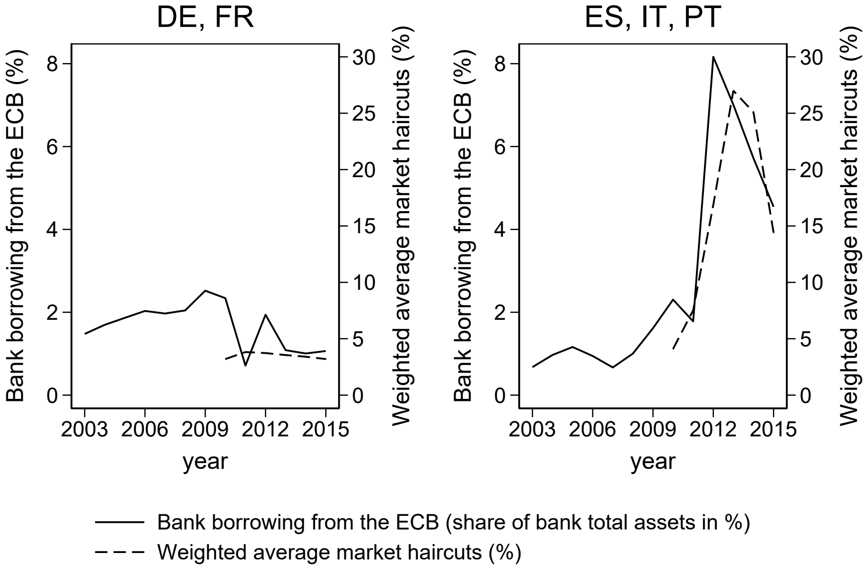


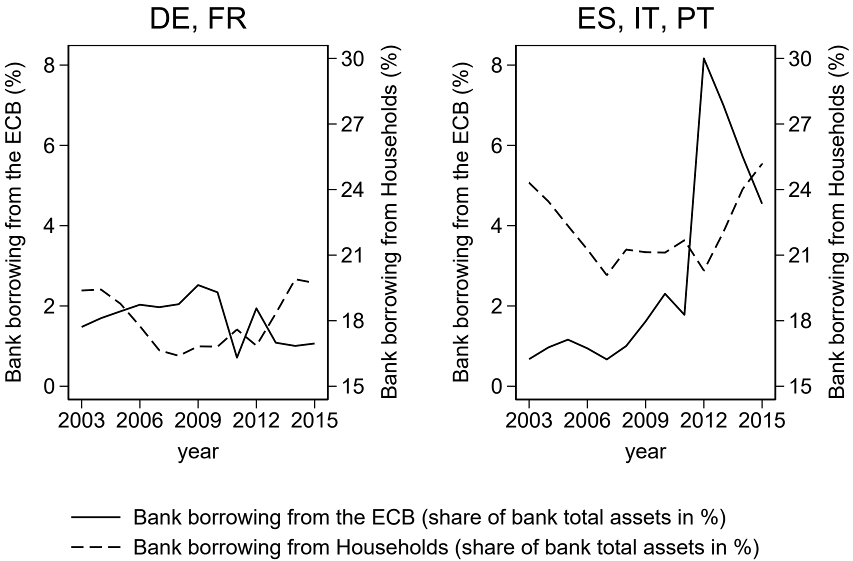
Obs. 2: Borrowing from ECB increased 8-fold in South.



Obs, 3: Increase in haircuts on Southern gov bonds



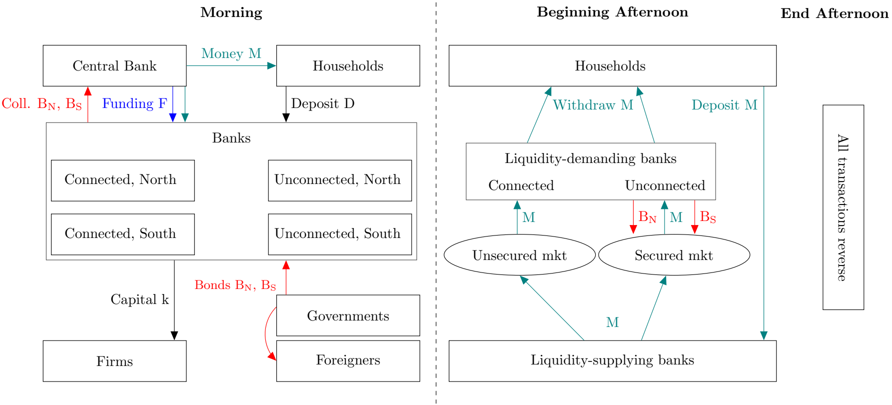
Observation 4: Household deposits remained stable



The model: overview.

- DSGE model with banks, st. Gertler-Karadi-Kiyotaki (**GKK**) leverage constraint, Bianchi-Bigio (**BB**) liquidity shocks, collateral constraints.
- $t = 0, 1, 2, \ldots$.
- **Morning**:
  - Households choose deposits, money, labor, consumption. Production.
  - Foreigners choose bonds.
  - Banks
    - collect returns. Pay dividends: fraction of net worth.
    - are randomly assigned to region j: **N**orth or **S**outh
    - ... and to be "**c**onnected" (prob. ξ_t) or "**u**nconnected" (prob. $1 - \xi_t$) .
    - Make portfolio choice: capital, reserves, bonds (of region), borrowing from CB, deposits. **GKK**. Coll. constraint vis-a-vis CB.
  - Aggregate capital is subject to adjustment costs.
- **Afternoon**: **BB**. Random withdrawals of deposits, re-deposited at end of afternoon. To satisfy withdrawals, banks
  - can borrow unsecured, if "connected".
  - can borrow against bonds s.t. haircut $1 - \tilde{\eta}_t^j$, if "unconnected".
  - can use their reserves ("money").
- Challenge: the interaction of the constraints.

The model: overview



Four Main Forces

1. **Capital Crowding Out Effect.** Buying more collateral (bonds, money) implies investing less in capital.
2. **Bond-Reserves Substitution Effect.** Banks shift from bonds to reserves as private haircuts rise or with more unconnected banks.
3. **North-South Liquidity Spillover Effect.** As Southern banks shift into reserves, reserves get scarcer, forcing Northern banks to shift out of reserves and into bonds.
4. **Haircut Gap Effect.** With CB haircuts below private haircuts, banks rely more on CB funding.

Details. The "boring bits"

- **Households:**
  - $u(c_t, h_t) = \log(c_t) - \frac{h_t^{1+\zeta}}{1+\zeta} + \frac{1}{\chi} \log\left(\frac{M_t^h}{P_t}\right)$
  - Can hold bank deposits at risk-free rate i_t^d, and money
- **Final Goods Firms:**
  - Hire labor and rents capital from banks to produce output
  - Access to Cobb-Douglas production function
- **Capital-Producing Firms:**
  - $k_t = \Phi(i_t/k_{t-1})k_{t-1}$, where $\Phi' > 0$, $\Phi'' > 0$, $\Phi(\delta) = \delta$.
  - Sells at price Q_t^k to banks
- **Fiscal Policies:** entirely mechanical. Region $j \in \{N, S\}$:
  - Spending: $g_{t,j} = s_j g^*$. Common tax rate τ_t on labor income.
  - Debt change $\Delta\overline{B}_{t,j} = \alpha(s_j B^* - (1-\kappa)\overline{B}_{t-1,j})$
  - Budget constraint, with cross-region transfers $T_{t,j}$,

$$P_t s_j g^* + \kappa\overline{B}_{t-1,j} = s_j \tau_t W_t h_t + Q_t^j \Delta\overline{B}_{t,j} + s_j S_t + T_{t,j}$$

  - Summing up across regions,

$$P_t g^* + \kappa\overline{B}_{t-1} = \tau_t W_t h_t + (s_N Q_t^N + s_S Q_t^S)\Delta\overline{B}_t + S_t.$$

- **Foreign bond demand:** $\frac{B_{t,j}^w}{P_t} = \varkappa\left(1 + \frac{1}{\varrho}\log\left(\frac{R_{t+1}^j}{r^j \pi_{t+1}}\right)\right)$

The central bank

- CB balance sheet at t:

Assets	Liabilities
$Q_t^N B_{t,N}^C$ (North govt bond holdings)	$\overline{M}_t$ (reserves plus currency)
$Q_t^S B_{t,S}^C$ (South govt bond holdings)	
$Q_t^F \overline{F}_t$ (loans to banks)	E_t (equity)

- Collateralized loans to bank l: $F_{t,l} \leq \eta_t (Q_t^N B_{t,N,l}^F + Q_t^S B_{t,S,l}^F)$.
- CB chooses $B_{t,N}^C$, $B_{t,S}^C$, Q_t^F and haircut $1 - \eta_t$ regardless of region.
- Money ("M_0") supply rule

$$\bar{M}_t = \bar{M}_{t-1} \frac{P_t}{P_{t-1}} + Q_t^F \bar{F}_t - R_{t-1}^F Q_{t-1}^F \bar{F}_{t-1}$$

  Flow budget constraint implies seignorage payments to governments.
- Compare **B**enchmark to **A**lternative policy:
  - **B**: "collateralized credit operations" **B**enchmark. $\eta_t = 0.97$.
  - **A**: "constant balance sheet" **A**lternative. $\eta_t = 0$. Thus $F_{t,l} = 0$, $\frac{\bar{M}_t}{P_t} \equiv \bar{m}$

Bank decisions: timing

Consider bank l (Dropping time subscripts for ease of exposition):

- Morning (asset management) ("extended GKK"):
  - Collect returns on assets, pay depositors.
  - Net worth n. Pay dividends ϕn.
  - iid type ν shock: with prob ξ_t bank is "**c**onnected", else "**u**nconnected"
  - iid shock: bank holds **N**orth bonds or **S**outh bonds. $j \in \{N, S\}$.
  - given (ν, j), choice of assets (capital k_l, bonds $B_{\nu,j}$, money M_l) and liabilities (deposits D_l and CB loans F_l)

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  - given (ν, j), choice of assets (capital k_l, bonds $B_{\nu,j}$, money M_l) and liabilities (deposits D_l and CB loans F_l)
- Afternoon (liquidity management) ("extended BB"):
  - iid liquidity shock realizes, $\omega_l \leq \omega^{\max}$, share of deposit withdrawals
  - C banks: raise liquidity in the unsecured MM
  - U banks: can borrow in the secured MM or self-insure
  - reversed liquidity shock at end of afternoon, loans can all be repaid
  - returns accrue, resulting in different end-of period net worth $\tilde{N}_l$

End of morning: bank balance sheet

- Bank l balance sheet before paying dividends

Assets	Liabilities
$Q^k k_l$ (capital)	D_l (deposits)
$Q^j B_{\nu,j}$ (bond holdings)	$Q^F F_l$ (CB loans)
ϕN (dividends)	N (net worth)
M_l (reserves)	

- CB loans are collateralized

$$F_l \leq \eta Q^j B_{\nu,j}$$

and $1 - \eta$ is the haircut imposed by the CB regardless of region.

Morning: leverage constraint

- From here, denote banks by type $\nu \in \{c, u\}$ and region $j \in \{N, S\}$.
- Net worth at dawn tomorrow (with one-period bonds, CB loans):

$$\tilde{N}_{\nu,j} = R_k Q^k k_{\nu,j} + B_{\nu,j} + M_{\nu,j} - R_d D_{\nu,j} - F_{\nu,j}$$

- (Before-shocks) value at dawn tomorrow $\tilde{V}_{\nu,j}$, discounted to today:

$$\tilde{V}_{\nu,j} = \tilde{\psi} \tilde{N}_{\nu,j}$$

- End-of-the-morning value $V_{\nu,j}$:

$$V_{\nu,j} = \tilde{V}_{\nu,j} + \phi N$$

- Leverage constraint in the morning as in Gertler-Karadi (2011)

$$\lambda \left(Q^k k_{\nu,j} + Q^j B_{\nu,j} + M_{\nu,j} \right) \leq V_{\nu,j}$$

Afternoon: liquidity management

- iid liquidity shock $\omega \leq \omega^{\text{max}}$: share of deposit withdrawals.
- C banks raise liquidity in the unsecured MM
- U banks borrow in secured MM or self-insure. Afternoon constraint

$$\omega^{\text{max}} D_{\nu,j} \leq M_{\nu,j} + \widetilde{\eta}^j Q^j \left(B_{\nu,j} - B^F_{\nu,j} \right)$$

where $1 - \widetilde{\eta}^j$ is haircut set in private secured MM for region j.

Calibration

Calibrated Parameters

- $\omega^{max} = 0.1$; % HQLA/Assets of EU banks, 2012 Q4 (Source: EBA)
- $\kappa = 0.042$; match avg maturity EA sovereigns (6 years)
- $\varrho = 1.76$; estimates from Koijen et al (2021)
- $\eta = \tilde{\eta}^N = \tilde{\eta}^S = 0.97$
- $R^F = 1.0025$
- $\xi = 0.42$ - observed unsecured share in 2007

Estimated Parameters

$$[\phi, \lambda, \chi, g^\star, \bar{b}] = \begin{cases} \text{gov bond spread}(\Lambda^\gamma) \\ \text{bank leverage} \\ \text{average inflation} \\ \text{gov. spending/GDP} \\ \text{share foreign sector for total debt} \end{cases}$$

Dynamics: Four Main Forces

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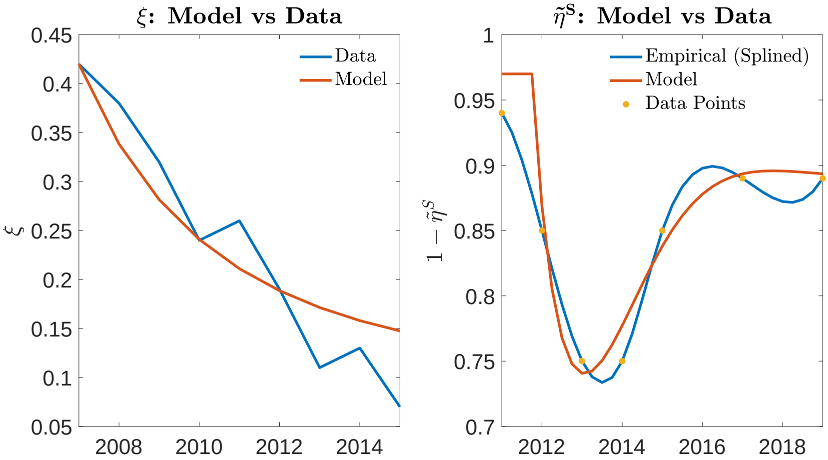
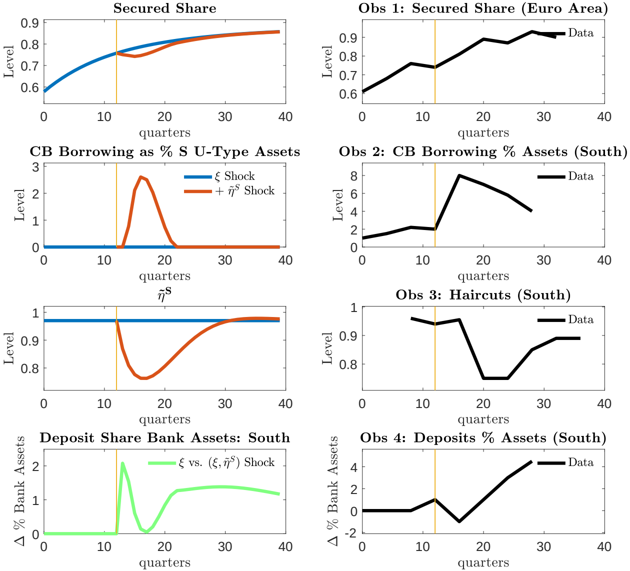
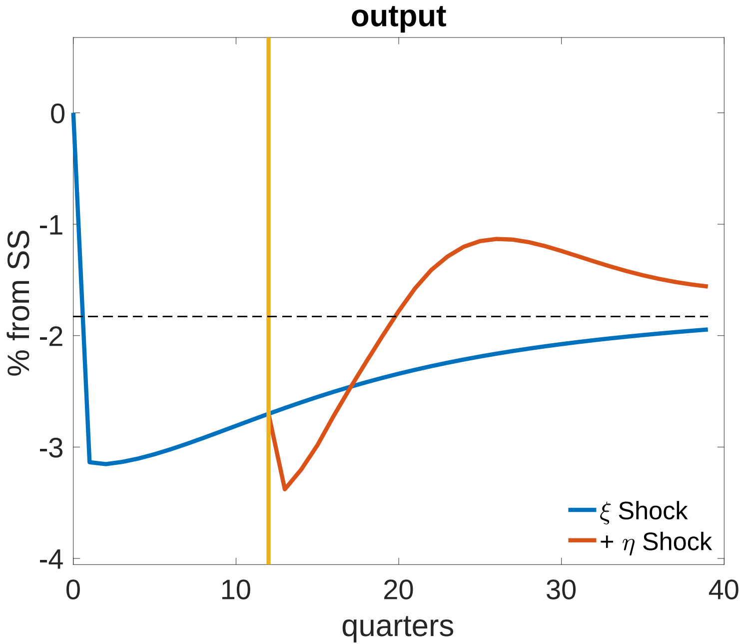
Evolution of $(1 - \xi_t)$ and $\tilde{\eta}^S$: Model Assumption vs Data



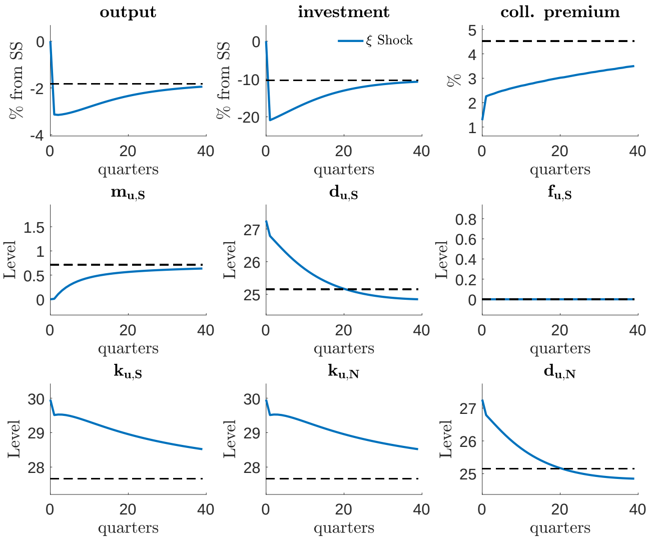
Four facts: model vs data, ξ_t only vs $\xi_t + \tilde{\eta}$ shock



Impulse Responses: ξ_t only vs $\xi_t + \tilde{\eta}$ shock

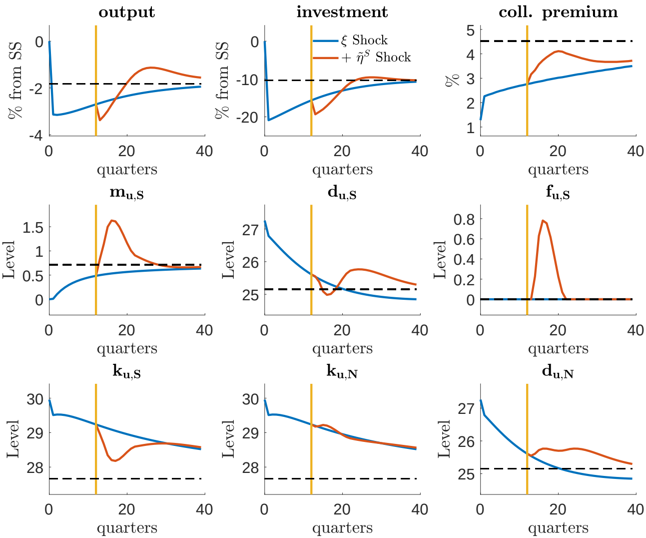


Impulse Responses: ξ_t only (blue)



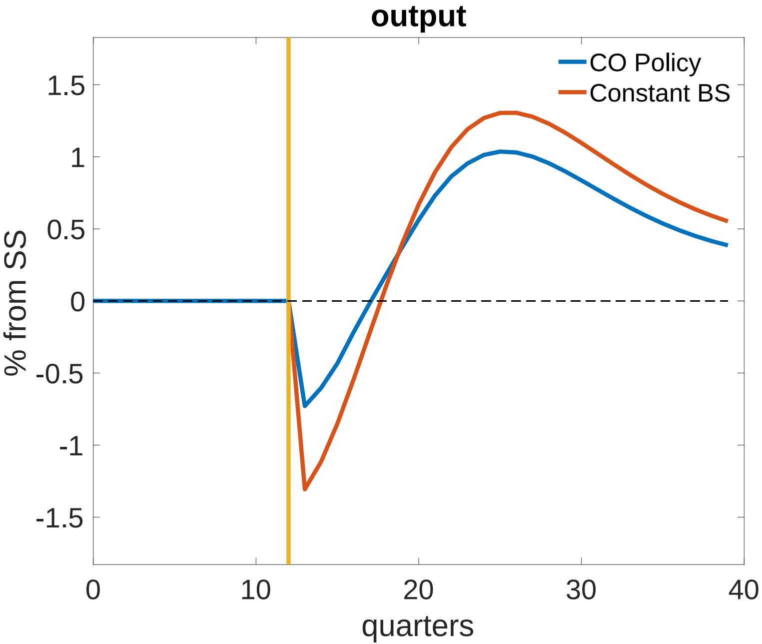
Impulse Responses: Shock to ξ_t Realised at $t = 0$

Impulse Responses: ξ_t only vs $\xi_t + \tilde{\eta}$ shock



Impulse Responses: Shock to ξ_t at $t = 0$ + to $\tilde{\eta}^S$ at $t = 13$

Impulse Resp.: **B**enchmark vs **A**lternative, rel to ξ_t only.



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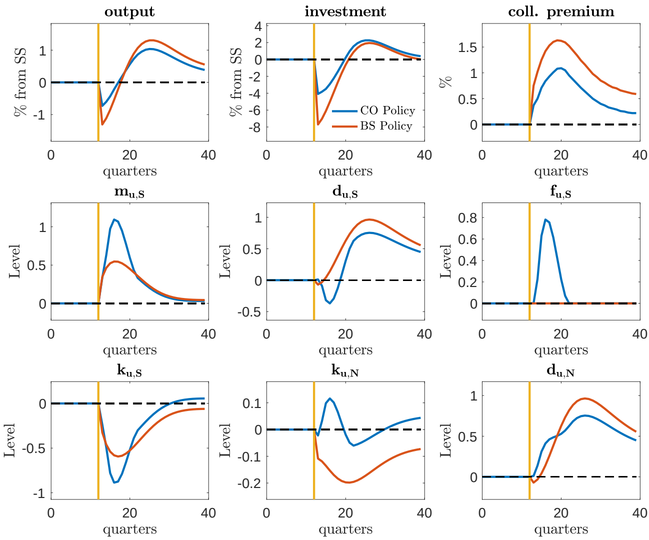

Summary

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ADDITIONAL SLIDES

Bank problem

Define $R_b^j = 1/Q^j$ and $R_F = 1/Q^F$. Banks solve

$$\max_{B_{\nu,j}, M_{\nu,j}, D_{\nu,j}, F_{\nu,j}} \tilde{V}_{\nu,j}$$

s.t.

$$\begin{aligned}
\tilde{N}_{\nu,j} &= (R_k - R_d)\, D_{\nu,j} + (R_k - R_f)\, Q^F F_{\nu,j} \\
&\quad - \left(R_k - R_b^j\right) Q^j B_{\nu,j} - (R_k - 1)\, M_{\nu,j} + R_k\,(1-\phi)\, N \\
\tilde{V}_{\nu,j} &= \tilde{\psi} \tilde{N}_{\nu,j} \\
F_{\nu,j} &\leq \eta Q^j B^F_{\nu,j} \\
D_{\nu,j} + Q^F F_{\nu,j} &\leq \frac{\tilde{V}_{\nu,j} + \phi N}{\lambda} - (1-\phi) N
\end{aligned}$$

and, for **u**nconnected banks, afternoon constraint:

$$\omega^{\max} D_{u,j} \leq M_{u,j} + \widetilde{\eta}^j Q^j \left(B_{u,j} - B^F_{u,j}\right)$$

Connected banks: assets and liabilities

Assumptions:

$R_k \geq R_b^j \rightarrow$ Bonds command a collateral premium

$R_d \leq R_F \rightarrow$ Deposits are cheaper than CB funding

Choice of connected banks: $B_{c,j} = 0, M_{c,j} = 0, F_{c,j} = 0$. Thus,

$$D_{c,j} = \frac{\tilde{V}_{c,j} + \phi N}{\lambda} - (1 - \phi) N$$

and

$$Q^k k_{c,j} = \frac{\tilde{V}_{c,j} + \phi N}{\lambda}$$

Unconnected banks: funding for the afternoon

Afternoon funding, unconn. banks: $M_{u,j}$ or $B_{u,j}$, given $D_{u,j}$ and $F_{u,j}$

Key is the collateral premium vs liquidity premium

$$\Lambda_j = \omega^{\max} \frac{R_k - R_b^j}{\tilde{\eta}^j} \text{ vs } \Lambda_M = \omega^{\max}(R_k - 1)$$

$\Lambda_j > \Lambda_M$ Money is cheaper than bonds:

$$B_{u,j} = F_{u,j}/(Q^j \eta) \quad \textit{and} \quad M_{u,j} = \omega^{\max} D_{u,j}$$

$\Lambda_j < \Lambda_M$ Bonds are cheaper than money:

$$M_{u,j} = 0 \quad \textit{and} \quad B_{u,j} = \frac{\omega^{\max}}{Q^j \tilde{\eta}^j} D_{u,j} + \frac{1}{Q^j \eta} F_{u,j}$$

$\Lambda_j = \Lambda_M$ Any $B_{u,j}$ and $M_{u,j}$ satisfying afternoon constraint

Unconnected banks: liabilities in the morning

Morning choice unconn. banks: $D_{u,j}$ and $F_{u,j}$ for given returns

- An additional unit of deposits D_u earns

$$X_d = R_k - R_d - \min\{\Lambda_j, \Lambda_M\}$$

- An additional unit of CB funding F_u earns

$$X_f = R_k - R_f - \frac{R_k - R_b^j}{\eta}$$

Unconnected banks: liabilities in the morning [cont'd]

If $\max\{X_d, X_f\} > 0$, leverage constraint holds with equality and if

$X_d > X_f$:

$$F_{u,j} = 0 \qquad D_{u,j} = \frac{\tilde{V}_{u,j} + \phi N}{\lambda} - (1 - \phi) N$$

$X_d < X_f$:

$$D_{u,j} = 0 \qquad F_{u,j} = \frac{\tilde{V}_{u,j} + \phi N}{\lambda} - (1 - \phi) N$$

$X_d = X_f$: any $D_{u,j}$ and $F_{u,j}$ satisfying leverage constr as equality

Unconnected banks: liabilities in the morning [cont'd]

If $\max\{X_d, X_f\} = 0$, leverage constr holds with inequality and if

$X_d > X_f$: $F_{u,j} = 0$ and $D_{u,j}$ anywhere between 0 and

$$D_{u,j}^{\max} = \frac{\tilde{V}_{u,j} + \phi N}{\lambda} - (1 - \phi) N$$

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$$F_{u,j}^{\max} = \frac{\tilde{V}_{u,j} + \phi N}{\lambda} - (1 - \phi) N$$

$X_d = X_f = 0$: any $D_{u,j} \geq 0$ and $F_{u,j} \geq 0$ satisfying leverage constr

$\max\{X_d, X_f\} < 0$: $D_{u,j} = F_{u,j} = 0$

Parameter values

Parameter	Description	Value
θ	Capital share in income	0.330
δ	Capital depreciation rate	0.020
β	Discount rate households	0.994
ϵ	Inverse Frisch elasticity	0.400
χ^{-1}	Coefficient in households' utility	0.006
g	Government spending	0.566
κ^{-1}	Average maturity bonds (years)	5.952
ϕ	Fraction net worth paid as dividends	0.025
ξ_t	Fraction banks with access to unsecured market	0.420
$\widetilde{\eta}$	Haircut on bonds set by banks	0.970
η	Haircut on bonds set by central bank	0.970
λ	Share of assets bankers can run away with	0.701
$\omega^{\max}$	Max possible liquidity demand as share of deposits	0.100
$\varkappa$	Intercept foreign demand function	10.120
B_C	Bonds held by central bank	0.968
B^*	Stock of debt	7.443
ϱ	Parameter foreign bond demand	1.757
Q^F	Price central bank loans	0.997
	Share of South	1/3

Calibration

Targeted variables	Data	Model
Govt expenditure/GDP	0.20	0.20
Bank leverage	6.00	6.00
Govt bond spread (annual)	0.002	0.002
Share bonds held by banks	0.23	0.23
Share bonds foreign sector	0.64	0.64
Inflation (annual)	0.02	0.02

Non-targeted variables	Data	Model
CB bond holdings/GDP	0.06	0.08
Govt debt/GDP	0.69	0.66

Baseline Steady State Values

Table: Aggregate

Variable	Value	Variable	Value
y	2.830	c	1.651
i	0.625	k	31.26
R^k	1.0099	Λ_S	**0.13%**
Λ_N	**0.13%**	Λ_M	**0.15%**

Variable	Value	Variable	Value
$k_{u,N}$	**29.99**	$k_{c,N}$	**33.01**
$d_{u,N}$	27.32	$d_{c,N}$	27.53
$b_{u,N}$	**2.952**	$b_{c,N}$	0
$m_{u,N}$	0	$m_{c,N}$	0
$f_{u,N}$	0	$f_{c,N}$	0
$n_{u,N}$	5.605	$n_{c,N}$	5.642

Steady State Comp Stat: the Constraints for U-Banks

- Liquidity constraint for unconnected banks binds:

$$\omega^{\max} D_{u,j} = M_{u,j} + \widetilde{\eta} Q^j \left(B_{u,j} - B_{u,j}^F \right)$$

- Five inequality constraints (switch off/on)
  - Gertler-Kiyotaki-Karadi leverage constraint:

$$\text{(\textbf{blue:})} \; V_{u,j} \geq \lambda \left(Q^k k_{u,j} + Q^j B_{u,j} + M_{u,j} \right)$$

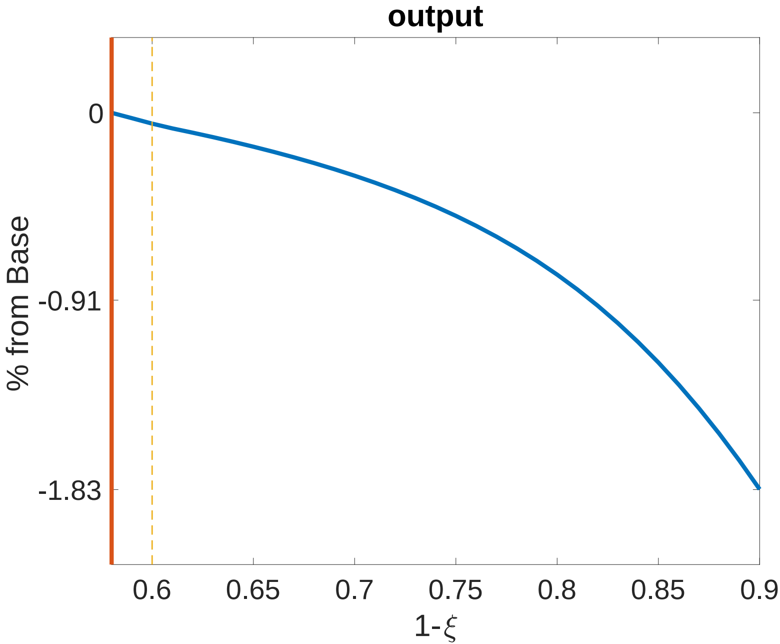
  - Collateral constraint at the CB in the morning:

$$\text{(\textbf{green:})} \; B_{u,j}^F \leq B_{u,j}$$

  - Short-sale constraints:

$$\begin{aligned} \rightarrow \text{(\textbf{orange:})} \quad & M_{u,j} && \geq 0 \\ \text{(\textbf{purple:})} \quad & F_{u,j} && \geq 0 \\ \text{(\textbf{brown:})} \quad & B_{u,j} && \geq 0 \end{aligned}$$

Steady State Comparative Statics, **B**enchmark. Vary $1-\xi$



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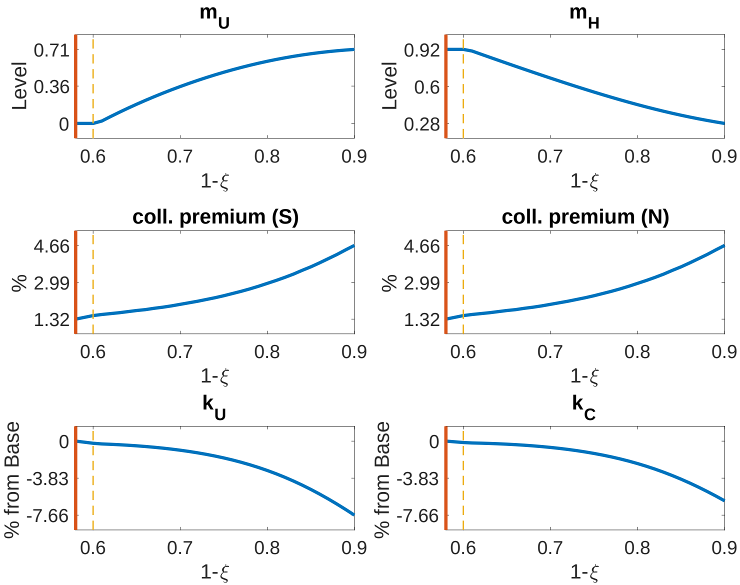
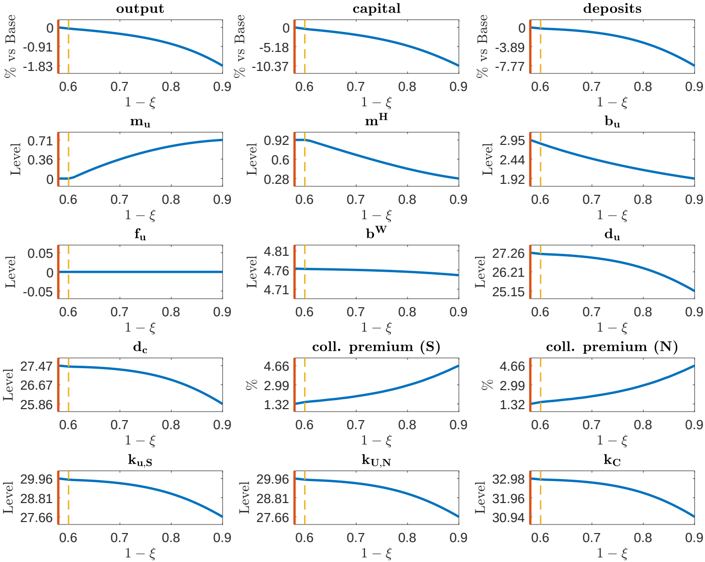


Steady State Comparative Statics, **B**enchmark. Vary $1-\xi$



Steady State Comp Stat: the Constraints for U-Banks

- Liquidity constraint for unconnected banks binds:

$$\omega^{\max} D_{u,j} = M_{u,j} + \widetilde{\eta} Q^j \left(B_{u,j} - B^F_{u,j} \right)$$

- Five inequality constraints (switch off/on)
  - Gertler-Kiyotaki-Karadi leverage constraint:

$$(\textbf{blue:})\ V_{u,j} \geq \lambda \left(Q^k k_{u,j} + Q^j B_{u,j} + M_{u,j} \right)$$

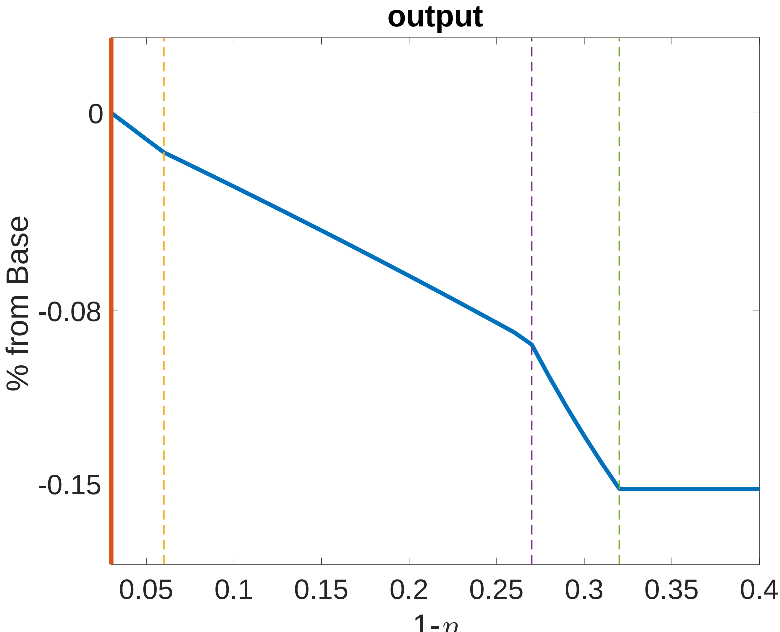
  - Collateral constraint at the CB in the morning:

$$\rightarrow (\textbf{green:})\ B^F_{u,j} \leq B_{u,j}$$

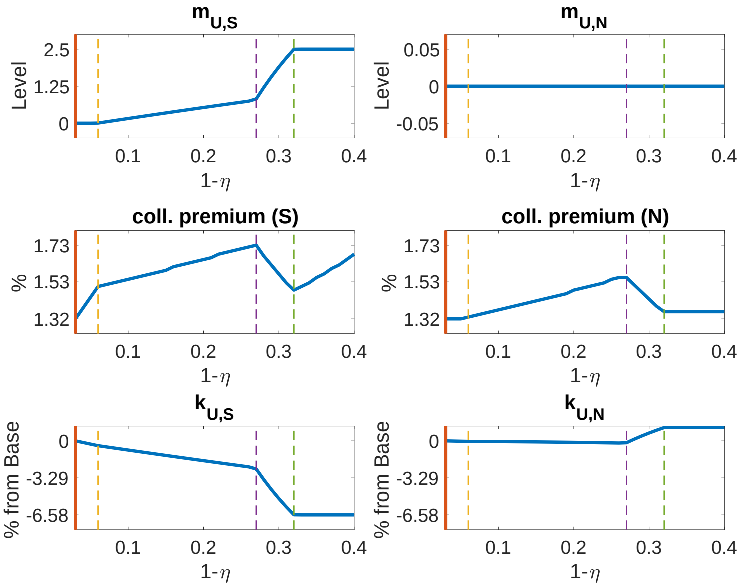
  - Short-sale constraints:

$$\begin{aligned} \rightarrow (\textbf{orange:}) \quad M_{u,j} &\geq 0 \\ \rightarrow (\textbf{purple:}) \quad F_{u,j} &\geq 0 \\ (\textbf{brown:}) \quad B_{u,j} &\geq 0 \end{aligned}$$

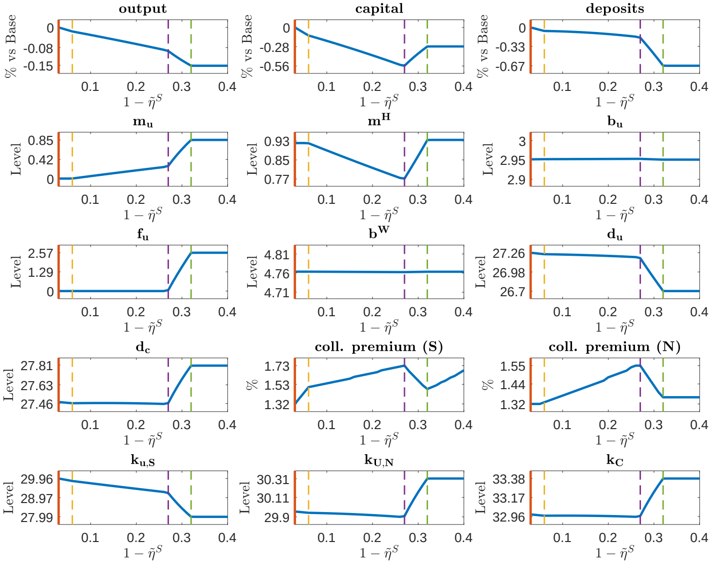
Steady State Comp. Statics, **B**enchmark. Vary $1-\tilde{\eta}^S$



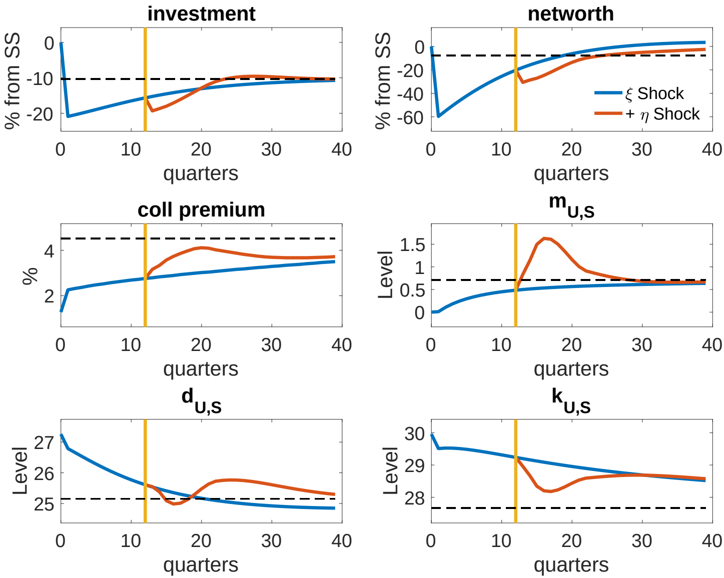
Steady State Comp. Statics, **B**enchmark. Vary $1 - \tilde{\eta}^S$



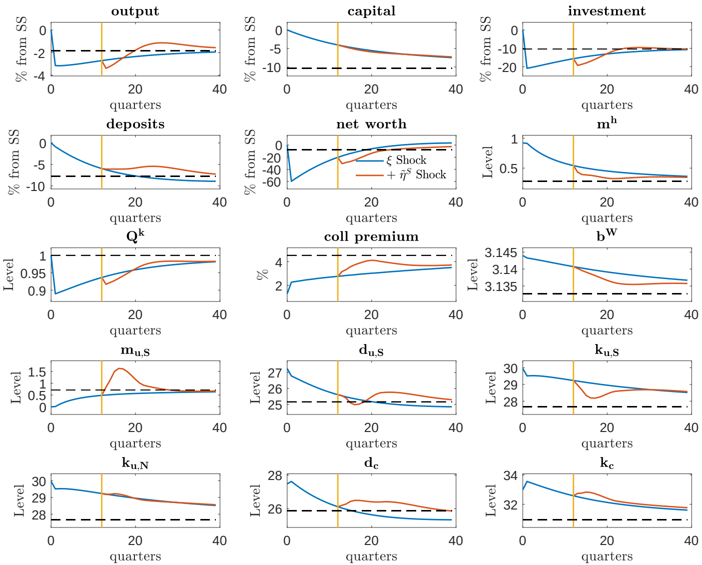
Steady State Comp. Statics, **B**enchmark. Vary $1 - \tilde{\eta}^S$



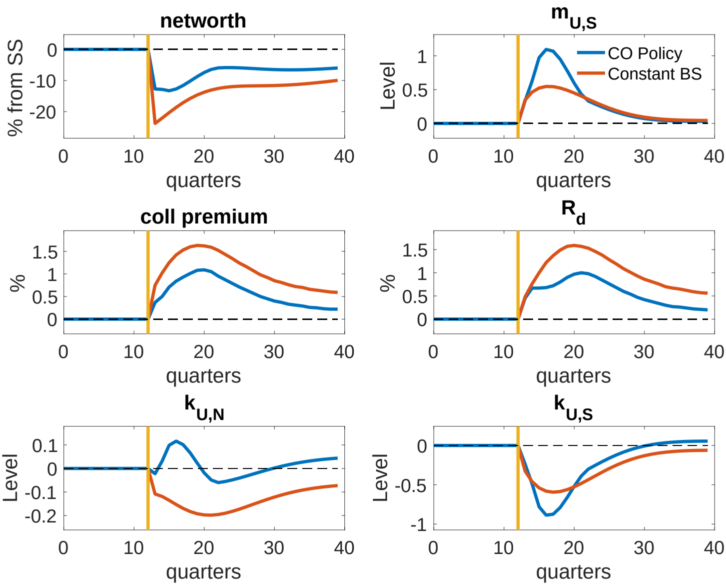
Impulse Responses: ξ_t only vs $\xi_t + \tilde{\eta}$ shock



Impulse Responses: ξ_t only vs $\xi_t + \tilde{\eta}$ shock



Impulse Resp.: **B**enchmark vs **A**lternative, rel to ξ_t only.



Impulse Resp.: **B**enchmark vs **A**lternative, rel to ξ_t only.