Quantitative Tightening

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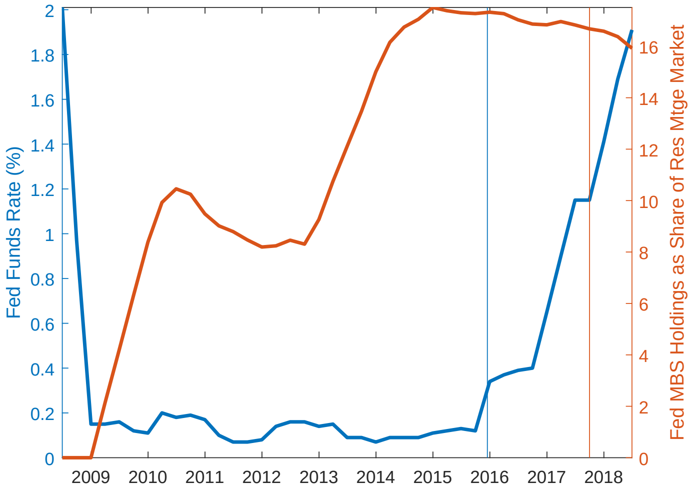
Motivation



Fed Funds Rate (%)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Fed MBS Holdings as Share of Res Mtge Market
16
14
12
10
8
6
4
2
0

Motivation

Monetary policy normalization in the US

- Interest rate lift-off (conventional)
- Balance sheet unwinding (unconventional)

We ask:

- **How do they interact?**
- When, which, and how much?
- What if there is a new crisis?
- What if there are political constraints?

What we do and how

We study these questions by doing the following:

- Model of (un)conventional monetary policy
  1. TANK w/ rich mortgage setting
  2. Endogenous refinancing decisions and mortgage duration
  3. Crisis = worsening of issuance frictions
- Quantitative analysis of normalization scenarios
  1. Early unwinding
  2. Late unwinding
  3. New crisis in 2019Q2
  4. QE4 and institutional constraints

Preliminary Results

Trade-off: fragility vs. redistribution

Unwinding later

- Enables policy-fueled temporary housing and consumption boom
- All fine (for borrowers) *if there is no new crisis*
- Political constraints more likely to bind $\Rightarrow$ crisis might be worse

Unwinding *earlier*

- Has only mild short-run costs
- Provides "room" for QE4

Precautionary benefits of unwinding soon after exiting ZLB.

Model

Demographics and Preferences

- Discrete time $t = 0, 1, \ldots$
- Impatient borrowers $j = b$, patient savers $j = s$
- Borrowers take out realistic mortgages
- Savers issue mortgages subject to frictions
- Preferences over numeraire, housing, labor

$$\mathcal{U}_t^j = \mathbb{E}_t \sum_{k=0}^{\infty} \beta_j^t \left[\log C_{t+k}^j + \xi \log H_{t-1+k}^j - \eta_j \frac{(N_{t+k}^j)^{1+\varphi}}{1+\varphi} \right]$$

Borrowers take out realistic mortgages

- Long-term fixed-rate nominal mortgage w/ costly prepayment
  - Mortgage consists of two payment streams
    - Principal ν, $(1-\nu)\nu$, $(1-\nu)^2\nu$, $\ldots \implies$ stock denoted by m_t
    - Interest r^*, $(1-\nu)r^*$, $(1-\nu)^2 r^*$, $\ldots \implies$ stock denoted by x_t
  - Mortgages can be prepaid at par, extinguishing both streams
- Endogenous prepayment with time-varying incentives
- New (and only new) mortgages subject to LTV constraint

Borrower Problem

Borrowers take out realistic mortgages

- Long-term fixed-rate nominal mortgage w/ costly prepayment
- Endogenous prepayment with time-varying incentives
  - **Family Construct**: continuum of members $i \in [0, 1]$ in borrower hh
  -
  - Prepaying allows member i to (i) optimize over house size h_t^*, (ii) optimize over mortgage size m_t^*, (iii) reset interest rate r_t^*
  - subject to iid cost $\kappa_{i,t} \sim \Gamma$ (rebated lump-sum back to borrowers)
  - Guess and verify optimal threshold policy: refinance when $\kappa_{i,t} < \kappa_t^*$
  - $\implies$ endogenous prepayment rate ρ_t

$$\rho_t \equiv \Gamma(\kappa_t^*) = F(\overbrace{\text{rate incentive}_t}^{+}, \overbrace{\text{cash-out motive}_t}^{+})$$

- New (and only new) mortgages subject to LTV constraint

Borrower Problem

Borrowers take out realistic mortgages

- Long-term fixed-rate nominal mortgage w/ costly prepayment
- Endogenous prepayment with time-varying incentives
- New (and only new) mortgages subject to LTV constraint

Borrower Problem

Savers originate mortgages subject to frictions

- New mortgages ℓ_t^* tranched: ℓ_t^* of **PO strips**, $r_t^* \ell_t^*$ of **IO strips**
- Origination + securitization subject to a cost (rebated lump-sum)

$$\Psi_t^S(\ell_t^*) = \frac{\eta_{m,t}}{1+\psi^m} \left(\frac{\ell_t^*}{\ell_{ss}^*} \right)^{1+\psi^m}, \qquad \eta_{m,t} \sim \text{AR}(1)$$

- Saver assets:
  1. PO strips m_t^s traded at price q_t^m with payoff

$$Z_t^m = \underbrace{\nu}_{\text{sched. principal}} + \underbrace{(1-\nu)\rho_t}_{\text{unsched. principal}} + \underbrace{(1-\nu)(1-\rho_t)q_t^m}_{\text{value of future payments}}$$

  2. IO strips x_t^s traded at price q_t^a with payoff

$$Z_t^a = \underbrace{1}_{\text{sched. interest}} + \underbrace{(1-\nu)(1-\rho_t)q_t^a}_{\text{value of future payments}}$$

  3. One-period nominal treasury debt b_t^s at price q_t, payoff equal to 1
- Savers otherwise identical to the rep agent in a standard NK model.

Firms and Govt Budget Constraint

- Continuum of intermediate producers
  - Linear production function $Y_t = A_t N_t$
  - Rotemberg price rigidity $\Rightarrow$ standard New Keynesian Phillips Curve
- Consolidated government budget constraint

$$T_t + q_t B_t^G + \text{Net QE Income}_t = G + \Pi_t^{-1} B_{t-1}^G$$

- Lump-sum taxes adjust to balance budget

$$T_t = \bar{T} \left(\frac{B_t^G}{\bar{B}_t^G} \right)^{\phi_T}$$

Conventional and Unconventional MP

Conventional: Taylor Rule subject to the ZLB

$$\frac{1}{q_t} = \max\left\{0, \left[\frac{1}{q_{t-1}}\right]^{\rho_i} \left[\frac{1}{\bar{q}}\left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\phi_\pi}\left(\frac{Y_t}{\bar{Y}}\right)^{\phi_y}\right]^{1-\rho_i} mp_t\right\}$$

Unconventional MP: Fed buys fraction f_t^{QE} of *newly issued* PO & IO

$$m_t^G = f_t^{QE}\ell_t^* + (1-\nu)(1-\rho_t)\Pi_t^{-1}m_{t-1}^G$$
$$x_t^G = f_t^{QE}r_t^*\ell_t^* + (1-\nu)(1-\rho_t)\Pi_t^{-1}x_{t-1}^G$$

Net income follows

$$\text{Net QE Income}_t = \Pi_t^{-1}(Z_t^m m_{t-1}^G + Z_t^a x_{t-1}^G) - (q_t^m m_t^G + q_t^a x_t^G)$$

Market Clearing

$$
\begin{aligned}
\text{Housing:} \quad & \chi H_t^B + (1-\chi)\bar{H}^S = 1 \\
\text{New Originations:} \quad & \chi \rho_t m_t^* = \ell_t^* = (1-\chi)\ell_t^{*,S} + f_t^{QE} \ell_t^* \\
\text{POs:} \quad & (1-\chi) m_t^S + m_t^G = \chi m_t \\
\text{IOs:} \quad & (1-\chi) x_t^S + x_t^G = \chi x_t \\
\text{Treasuries:} \quad & (1-\chi) b_t^S = B_t^G \\
\text{Labor:} \quad & \chi N_t^B + (1-\chi) N_t^s = N_t \\
\text{Final goods:} \quad & \chi C_t^B + (1-\chi) C_t^S + \delta p_t^h + G = Y_t
\end{aligned}
$$

Key Model Mechanisms

Refinancing Incentives

The FOC for refinancing can be written as

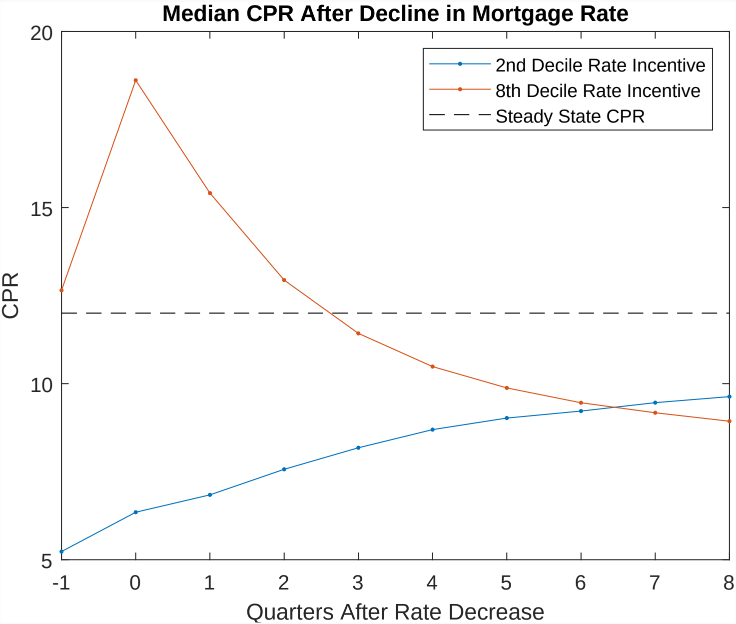
$$\kappa_t^* = \Omega_t^x(\bar{r}_t - r_t^*) + \mu_t \left[m_t^* - \Pi_t^{-1}(1-\nu) m_{t-1} \right]$$

where

- $\bar{r}_t = \frac{x_{t-1}}{m_{t-1}}$ is the avg interest rate of outstanding mortgages
- r_t^* is the current (new) mortgage rate
- Ω_t^x is the marginal value of future interest payments
- μ_t is the multiplier on the LTV constraint

$$\text{Refinancing Incentive}_t \simeq \text{Interest incentive}_t + \text{Cash-out incentive}_t$$

State Dependent Effects of Monetary Policy



Unconventional Monetary Policy

- QE acts by lowering origination + securitization costs
- FOC for originations:

$$q_t^m + q_t^a r_t^* = 1 + \eta_{m,t} \left[\frac{\rho_t m_t^* (1 - f_t^{QE})}{\rho_{ss} m_{ss}^*} \right]^{\psi^m}$$

- QE stabilizes r_t^*, refinancing $\uparrow$, borrower (current) income $\uparrow$, GDP $\uparrow$

Quantitative Analysis: Monetary Policy Normalization

Policy Normalization: Benchmark

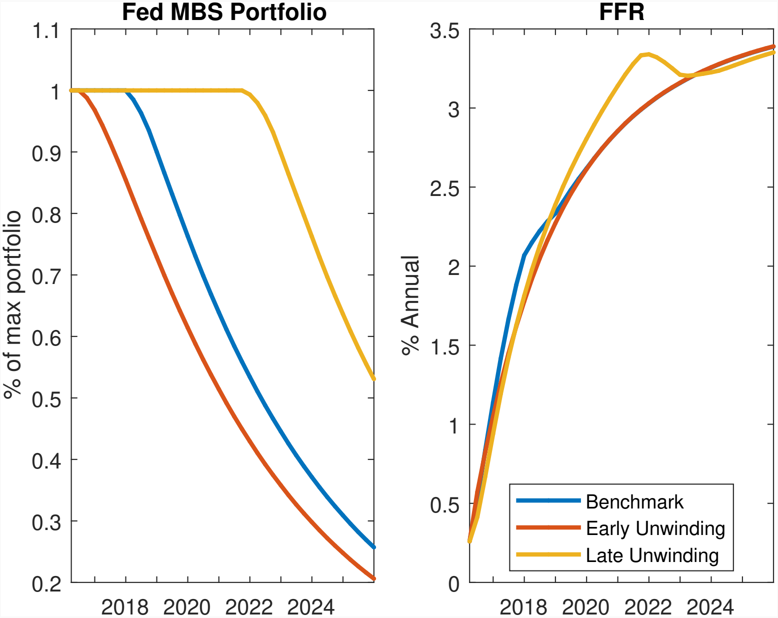
Study nonlinear transitions from state in 2015Q4 s.t.:

- No exogenous shocks from this point onwards
- Interest rate normalization follows Taylor Rule subject to ZLB
- QE normalization follows the September 2017 FOMC instructions
    1. Maintenance regime in 2015Q4-2017Q4, purchases are such that

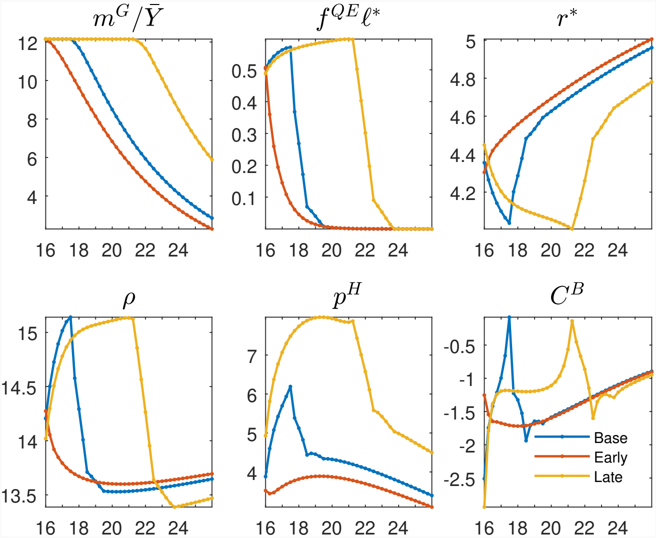
       $$m_t^G = m_{\max}^G$$

       where $m_{\max}^G$ is the size of MBS holdings as of 2015Q4
    2. Reinvestments subject to growing caps from 2017Q3 onwards
- Alternative Scenarios:
    1. *Early unwinding*, reinvestment caps start in 2015Q4
    2. *Late unwinding*, reinvestment caps start in 2020Q3

Policy Normalization Scenarios

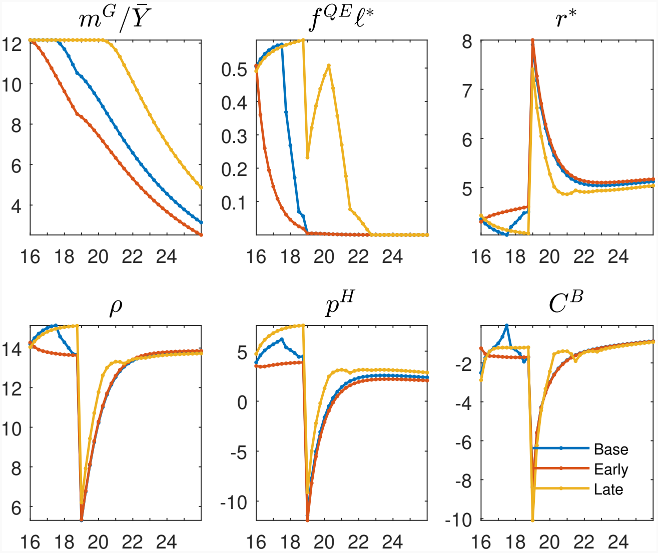


Policy Normalization



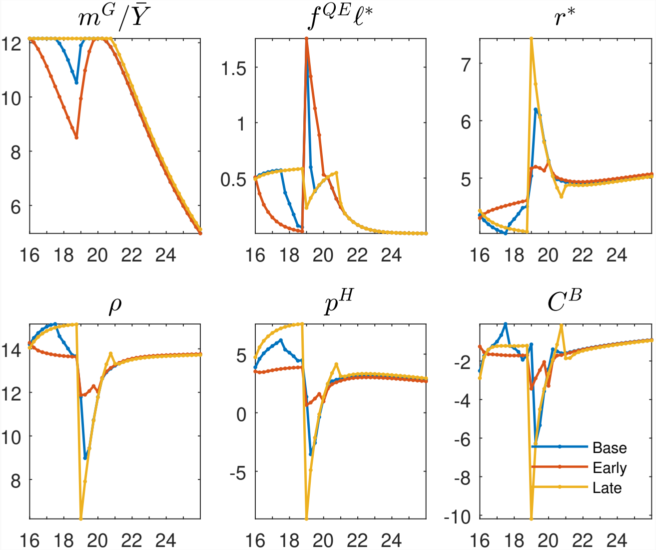
Other vars.

Policy Normalization: Unexpected Crisis in 2019Q2



▸ Other vars.

Policy Normalization: QE4 and Political Constraints



▸ Other vars.

Policy Normalization: QE4 and Political Constraints

	Benchmark	Early Unwinding	Late Unwinding
r_t^*	$+1.69$pp	$+0.64$pp	$+3.35$pp
p_t^h	-8.74%	-3.25%	-16.49%
C_t^B	-3.88%	-1.68%	-8.48%

Conclusion

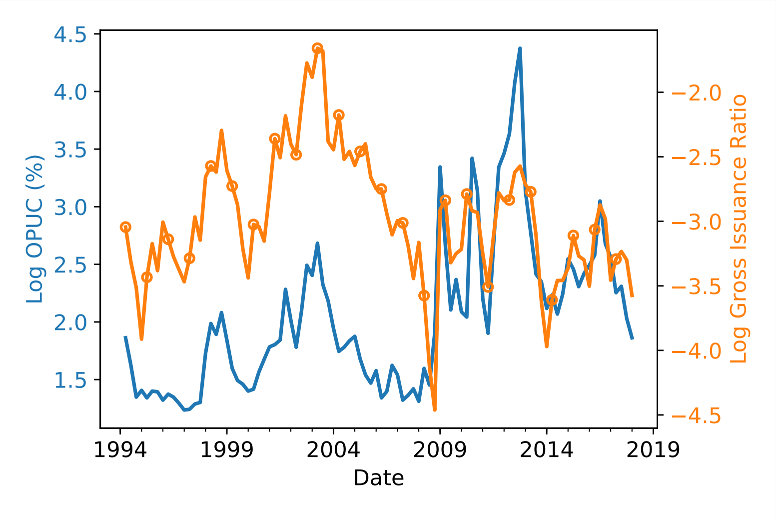
- Unwinding later: great for borrowers *if there is no new crisis*
- Political constraints more likely to bind $\Rightarrow$ crisis might be worse
- Unwinding earlier has mild short-run costs, "makes room" for QE4

Early stages! Next steps:

- Further explore feedback between unwinding and refinancing
- How does this affect interaction between conventional and unconventional MP?
- Portfolio composition: unwind MBS vs. treasuries

Appendix

Mortgage Spreads and Issuance Frictions



Relationship between originations and orig. costs changes after crisis.

Mortgage Spreads and Issuance Frictions, cont'd

- Data motivates functional form for issuance costs of the type

$$1 + \mathrm{Cost}_t = \exp\{\beta_{t,0} + \beta_{t,1} \log GIR_t\} = \eta_t GIR_t^{\psi_t}$$

- η_t, ψ_t rise during periods of financial stress ▸ Details on data/analysis
- Embed this relationship in a GE model with realistic mortgages
- QE moderates private GIR, issuance costs
- Reduced-form way of capturing QE effects

Mortgage Spreads and Issuance Frictions

How much of the variation in OPUCs can be explained by mortgage origination?

$$\log \mathrm{OPUC}_t = \beta_{s,0} + \beta_{s,1} \log \mathrm{GIR}_t + \epsilon_t, \quad s \in \{pre, post\}$$
$$\mathrm{GIR}_t = \frac{\mathrm{Mortgages}_t - (1 - \mathrm{Prepayment}_t) \cdot \mathrm{Mortgages}_{t-1}}{\mathrm{Mortgages}_{t-1}}$$

Sample	$\beta_{s,0}$	$\beta_{s,1}$	Adj. R^2	N
Pre (to 2008 Q2)	3.183***	0.536***	0.676	58
	(0.185)	(0.065)		
Post (since 2008 Q3)	6.318***	1.159***	0.517	38
	(0.853)	(0.262)		

pre is 1994 Q1 - 2008 Q2, *post* is 2008 Q3 - 2018 Q1 back

Calibration

Back

Parameter	Description	Value	Target
	Demographics and Preferences		
χ	Fraction of borrowers	0.45	Avg share w/ neg fixed income pos, SCF 93-16
β_s	Discount factor savers	0.9959	Avg level of federal funds rate 2000-2018
β_b	Discount factor borrowers	0.9829	Value of housing to income of 8.89
φ	Frisch elasticity	1	Standard
ξ	Housing preference parameter	0.25	Davis and Ortalo-Magne (2011)
η_b	Borrower labor disutility	14.13	$N_t^b = 0.33$
η_s	Saver labor disutility	8.28	$N_t^s = 0.33$
	Production		
ε	Micro elasticity of substitution across varieties	6	20% markup in SS
ζ	Rotemberg Menu Cost	98.37	Prices adjust once every five quarters
	Government		
$\bar{G}$	SS Govt. Spending	$0.2 \times Y$	20% for the US
$\bar{B}^g$	SS Govt. Debt	$0.14 \times Y$	Avg. maturity of 20 months, 70% of GDP
$\bar{\Pi}$	Trend Inflation	$1.02^{0.25}$	2% for the US
ϕ_π	Taylor rule: Inflation	1.5	Standard
ϕ_y	Taylor rule: Output	0.5/4	Standard
ρ_i	Taylor rule: Smoothing	0.8	Standard
ϕ_τ	Fiscal Rule	0.01	Faria-e-Castro (2018)
	Housing and Mortgages		
θ^{LTV}	Maximum LTV at origination	0.80	Max LTV for GSE conforming loans
ν	Contractual duration of mortgages	0.005	Standard
δ	Maintenance cost of housing	0.0065	2.5% annual, standard
$\bar{H}$	Total stock of housing	1	Normalization
s_κ	SD of prepayment shock	0.152	Greenwald (2018)
μ_κ	Mean of prepayment cost shock	0.2902	$\rho_{ss} = 0.0376$
$\eta_{m,ss}$	Mean financial friction	1.0969	Annual. mortgage spread of 2%
ϕ_m	Elasticity of Ψ to originations	2.5	
	Shock Parameters		
ρ_a	Persistence of TFP	0.90	Standard
σ_a	SD of TFP Innovations	0.01	Standard
ρ_i	Persistence of nominal rate	0.80	Standard
ρ_r	Persistence of MP Shock	0.80	Standard
σ_r	SD of MP Shock Innovations	0.005	Standard
ρ_{QE}	Persistence of QE	0.75	Estimated
σ_{QE}	SD of QE Innovations	1	Normalization
ρ_η	Persistence of financial shock	0.75	
σ_η	SD of financial shock Innovations	1	Normalization

Estimating the state of the US economy in 20154

- Standard state space methods
- Use Kalman Filter to estimate paths for states 2000Q1-2015Q4
- Four exogenous shocks

$$\{\varepsilon_t^a, \varepsilon_t^r, \varepsilon_t^m, \varepsilon_t^{QE}\}_{t=0}^T$$

- Four observables
  1. (Detrended) PCE consumption
  2. 3-month treasury bill rate
  3. Share of mortgages owned by the Fed
  4. Real mortgage growth

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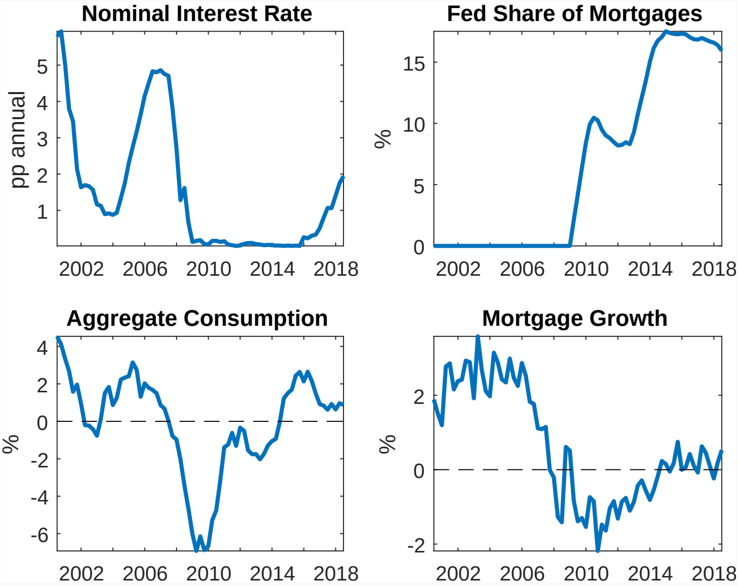
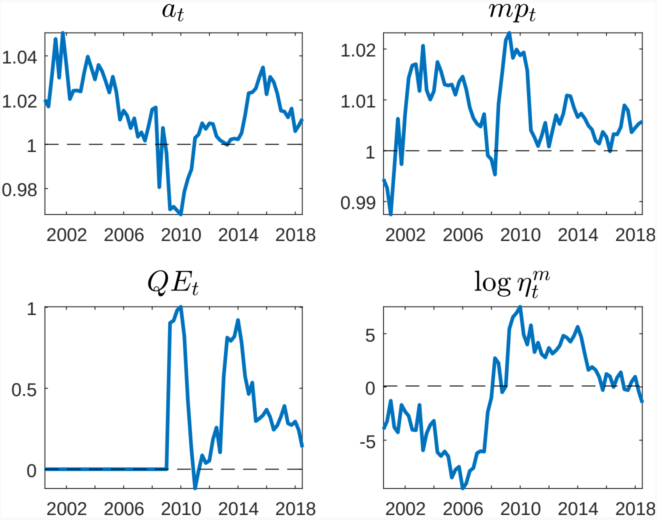
Data: Observables



Smoothed Exogenous Processes



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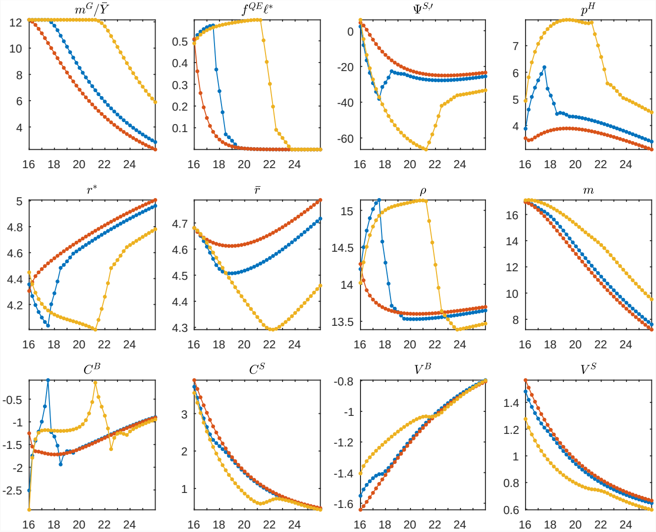
Policy Normalization



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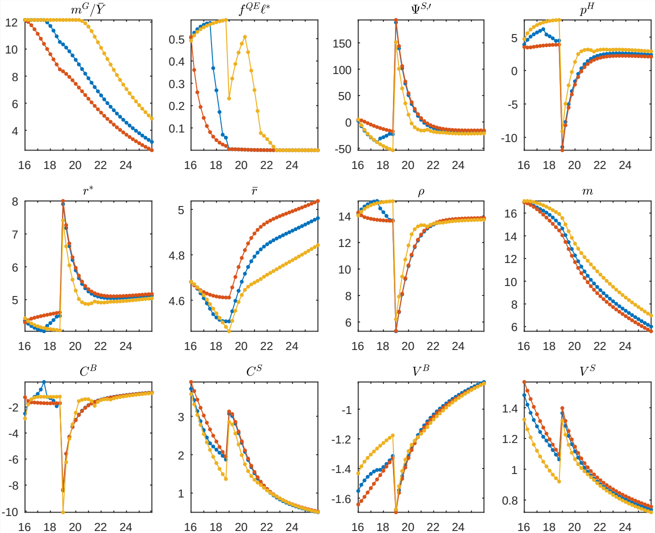
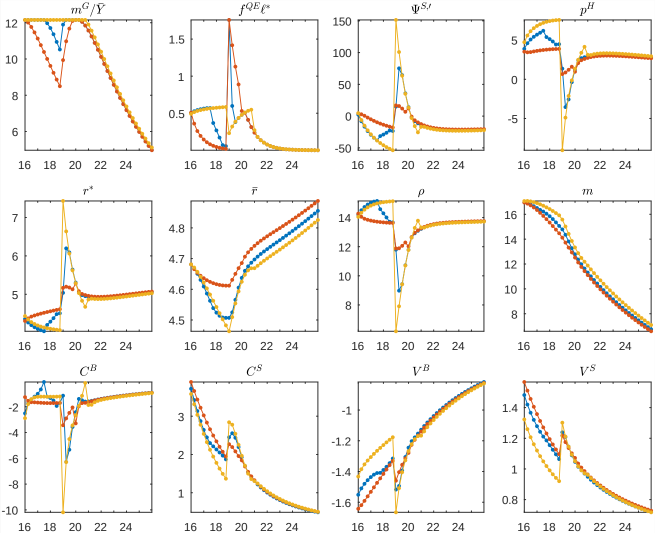
Policy Normalization: Unexpected Crisis in 2019Q2



Policy Normalization: QE4 and Political Constraints



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