# Quantitative Tightening

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*The views expressed on this paper do not necessarily reflect the positions of the Federal Reserve Bank of St. Louis or the Federal Reserve System.*

# Introduction

# Motivation

**Monetary policy normalization in the US**

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

We ask the following questions:

- 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

# Results

Unwinding later

- Enables housing, consumption boom
- All fine *if there is no new crisis*
- Political constraints more likely to bind $\Rightarrow$ crisis might be worse

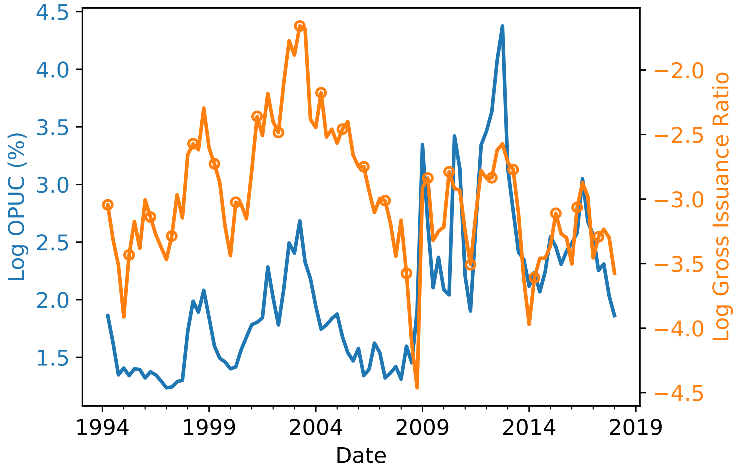
Unwinding *earlier*

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

**Precautionary benefits of unwinding soon after exiting ZLB.**

# Background: Mortgage Spreads

# Mortgage Spreads and Issuance Frictions




Relationship between originations and orig. costs <u>changes</u> after crisis.

# Mortgage Spreads and Issuance Frictions, cont'd

- Data motivates functional form for issuance costs of the type

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

- $\eta_t, \psi_t$ 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

# Model

# Demographics and Preferences

- Discrete time $t = 0, 1, \ldots$
- **Borrowing** $\implies$ 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
- **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)
- $\implies$ endogenous prepayment rate $\rho_t$

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

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

Full Borrower Problem

# Savers originate mortgages subject to frictions

- New mortgages $\ell_t^*$ tranched: $\ell_t^*$ 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 RA in a standard NK model.

## Firms and Government

- Continuum of intermediate producers
  - Linear production function $Y_t = A_t N_t$
  - Rotemberg frictions $\Rightarrow$ standard New Keynesian Phillips Curve
- Monetary policy ▸ MP Details
  - **Conventional**: Set short rate following Taylor rule with ZLB
  - **Unconventional**: Purchase fraction $f_t^{QE} \in [0, 1)$ of new originations
- 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 grow slowly when gov't debt above steady state

# Market Clearing

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

# Model Features

- Four aggregate shocks: $\{\text{TFP}_t, \text{MP}_t, \text{Origination}_t, \text{QE}_t\}$
- Refinancing $\text{Incentive}_t \simeq$ Interest $\text{incentive}_t$ + Cash-out $\text{incentive}_t$
  - State- and history-dependent effects of monetary policy

    ▸ State dependence of MP
- QE "works" by stabilizing $r_t^*$

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

$r_t^* \downarrow$, refinancing $\uparrow$, borrower (current) income $\uparrow$, GDP $\uparrow$

# Quantitative Analysis: Monetary Policy Normalization

# Design of the Experiment

Combine model and US data to study monetary policy normalization

1. Given the commitment to an interest rate rule, what are the effects of different balance sheet normalization plans?

2. Do these different plans matter should the US economy experience a new financial crisis?

3. Do these different plans matter if the Fed wants to engage in new asset purchases during a new crisis?

# Our approach

1. Calibrate the model to the US ▸ Calibration
2. Estimate the state of the US economy in 2015Q4 ▸ Details and Data
3. Use that state as a starting point to study counterfactual scenarios
   - Benchmark, unwinding starts in 2017Q4
   - Early unwinding, starting in 2015Q4
   - Late unwinding, starting in 2020Q4
   - Unexpected crisis in 2019Q2
   - QE4 in response to unexpected crisis

# Policy Normalization: Benchmark

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

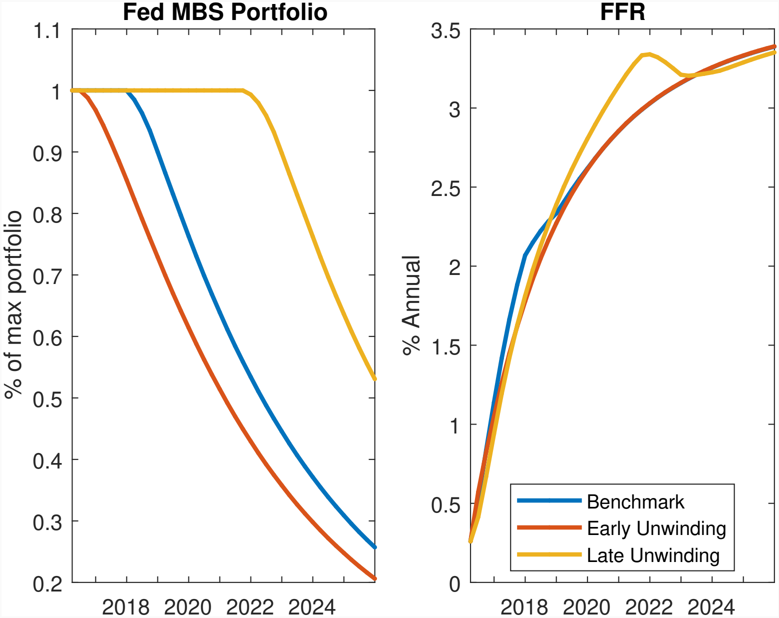
- No exogenous shocks from this point onwards
- Interest rate normalization follows Taylor Rule subject to ZLB
- QE normalization follows the September 2017 FOMC instructions
  1. Maintenance regime in 2015Q4-2017Q4, purchases are such that

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

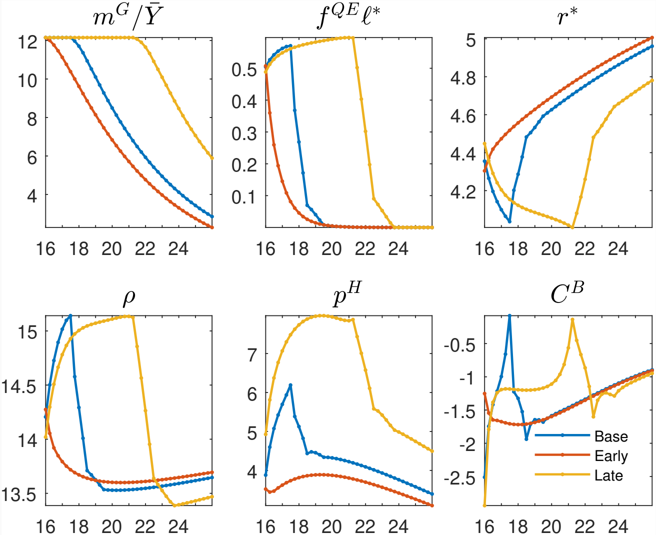
     where $m_{\max}^G$ is the size of MBS holdings as of 2015Q4

  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

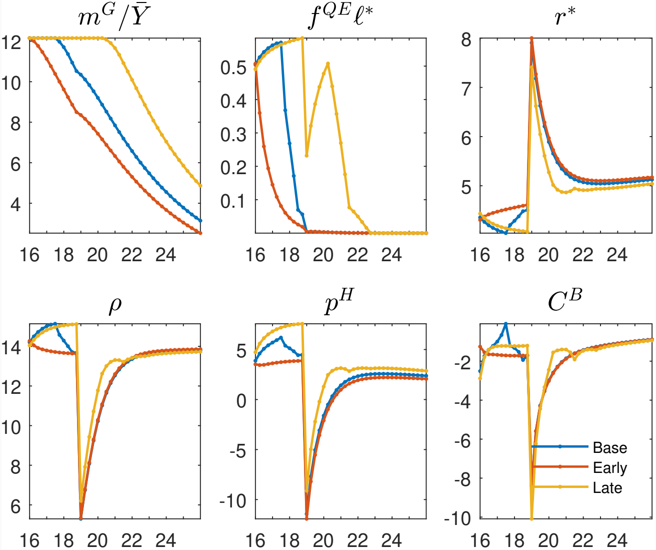


# Policy Normalization



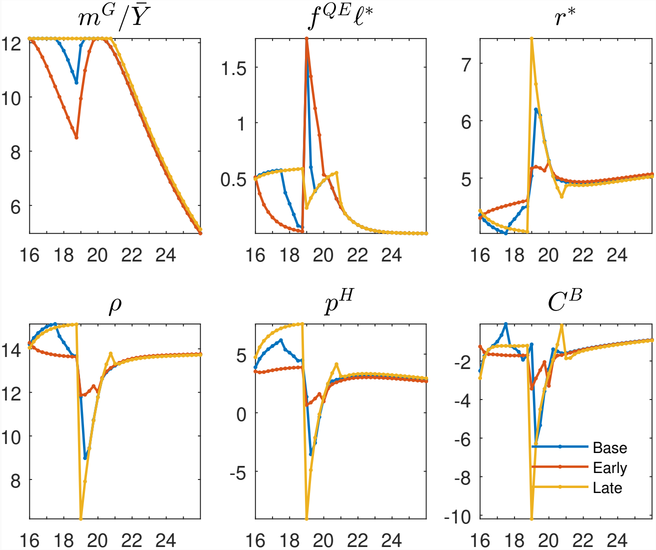

Other vars.

# 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

# Conclusion

- Unwinding later: everything fine *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

Very preliminary, work in progress!

# Appendix

# Mortgage Spreads and Issuance Frictions

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

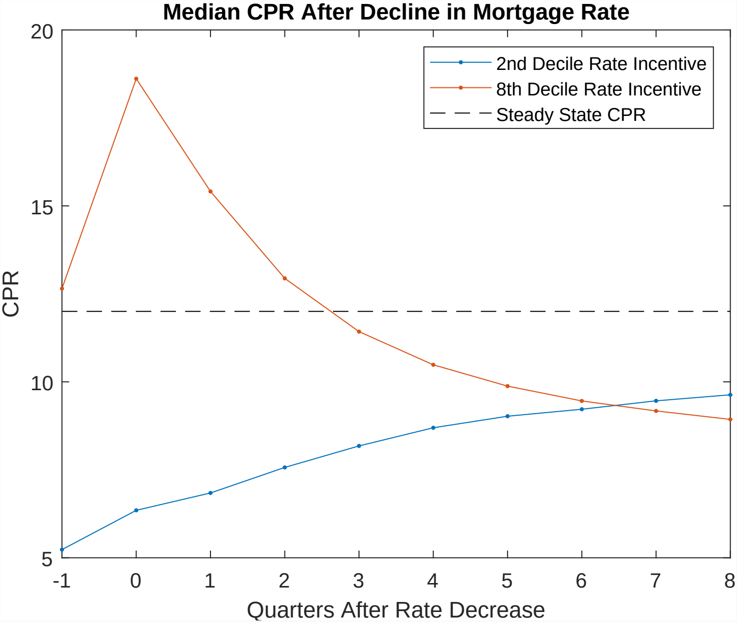
$$\log \mathrm{OPUC}_t = \beta_{s,0} + \beta_{s,1} \log \mathrm{GIR}_t + \epsilon_t, \quad s \in \{pre, post\}$$

$$\mathrm{GIR}_t = \frac{\mathrm{Mortgages}_t - (1 - \mathrm{Prepayment}_t) \cdot \mathrm{Mortgages}_{t-1}}{\mathrm{Mortgages}_{t-1}}$$

| 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

# State Dependent Effects of Monetary Policy



# Borrower Problem

$$\max_{C_t^b, H_t^b, N_t^b, m_t^*, h_t^*, \kappa_t^*} \mathcal{U}_t^j$$

s.t.

$$C_t^b + \underbrace{\rho_t p_t^h (h_t^{*,b} - h_{t-1}^b)}_{\text{New houses}} + \underbrace{\delta p_t^h h_t^{-1}}_{\text{Maintenance}} + T_t + \underbrace{\left(\Psi_t^B(\kappa_t^*) - \Psi_t^B(\cdot)\right)}_{\text{Rebated refi cost}}$$

$$= \underbrace{w_t N_t^b}_{\text{Labor income}} - \underbrace{\Pi_t^{-1}(x_{t-1}^b + \nu m_{t-1}^b)}_{\text{Mtge payments}} + \underbrace{\rho_t \left[ m_t^{*,b} - \Pi_t^{-1}(1-\nu) m_{t-1}^b \right]}_{\text{New borrowing}}$$

$$m_t^{*,b} \leq \theta^{LTV} p_t^h h_t^b$$

$$m_t^b = \rho_t m_t^* + (1-\rho_t)(1-\nu)\Pi_t^{-1} m_{t-1}^b$$

$$x_t^b = \rho_t r_t^* m_t^* + (1-\rho_t)(1-\nu)\Pi_t^{-1} x_{t-1}^b$$

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# 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

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

where

$$f_t^{QE} = \frac{QE_t - 1}{1 + QE_t}$$

$$\log QE_t = \rho_{QE}\log QE_{t-1} + \sigma_{QE}\varepsilon_t^{QE}$$

Net income follows

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

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# Calibration

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| Parameter | Description | Value | Target |
|---|---|---|---|
| | *Demographics and Preferences* | | |
| $\chi$ | Fraction of borrowers | 0.45 | Avg share w/ neg fixed income pos, SCF 93-16 |
| $\beta_s$ | Discount factor savers | 0.9959 | Avg level of federal funds rate 2000-2018 |
| $\beta_b$ | Discount factor borrowers | 0.9829 | Value of housing to income of 8.89 |
| $\varphi$ | Frisch elasticity | 1 | Standard |
| $\xi$ | Housing preference parameter | 0.25 | Davis and Ortalo-Magne (2011) |
| $\eta_b$ | Borrower labor disutility | 14.13 | $N_t^b = 0.33$ |
| $\eta_s$ | Saver labor disutility | 8.28 | $N_t^s = 0.33$ |
| | *Production* | | |
| $\varepsilon$ | Micro elasticity of substitution across varieties | 6 | 20% markup in SS |
| $\zeta$ | 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 |
| $\phi_\pi$ | Taylor rule: Inflation | 1.5 | Standard |
| $\phi_y$ | Taylor rule: Output | 0.5/4 | Standard |
| $\rho_i$ | Taylor rule: Smoothing | 0.8 | Standard |
| $\phi_\tau$ | Fiscal Rule | 0.01 | Faria-e-Castro (2018) |
| | *Housing and Mortgages* | | |
| $\theta^{LTV}$ | Maximum LTV at origination | 0.80 | Max LTV for GSE conforming loans |
| $\nu$ | Contractual duration of mortgages | 0.005 | Standard |
| $\delta$ | Maintenance cost of housing | 0.0065 | 2.5% annual, standard |
| $\bar{H}$ | Total stock of housing | 1 | Normalization |
| $s_\kappa$ | SD of prepayment shock | 0.152 | Greenwald (2018) |
| $\mu_\kappa$ | Mean of prepayment cost shock | 0.2902 | $\rho_{ss} = 0.0376$ |
| $\eta_{m,ss}$ | Mean financial friction | 1.0969 | Annual. mortgage spread of 2% |
| $\phi_m$ | Elasticity of $\Psi$ to originations | 2.5 | |
| | *Shock Parameters* | | |
| $\rho_a$ | Persistence of TFP | 0.90 | Standard |
| $\sigma_a$ | SD of TFP Innovations | 0.01 | Standard |
| $\rho_i$ | Persistence of nominal rate | 0.80 | Standard |
| $\rho_r$ | Persistence of MP Shock | 0.80 | Standard |
| $\sigma_r$ | SD of MP Shock Innovations | 0.005 | Standard |
| $\rho_{QE}$ | Persistence of QE | 0.75 | Estimated |
| $\sigma_{QE}$ | SD of QE Innovations | 1 | Normalization |
| $\rho_\eta$ | Persistence of financial shock | 0.75 | |
| $\sigma_\eta$ | 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

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

- 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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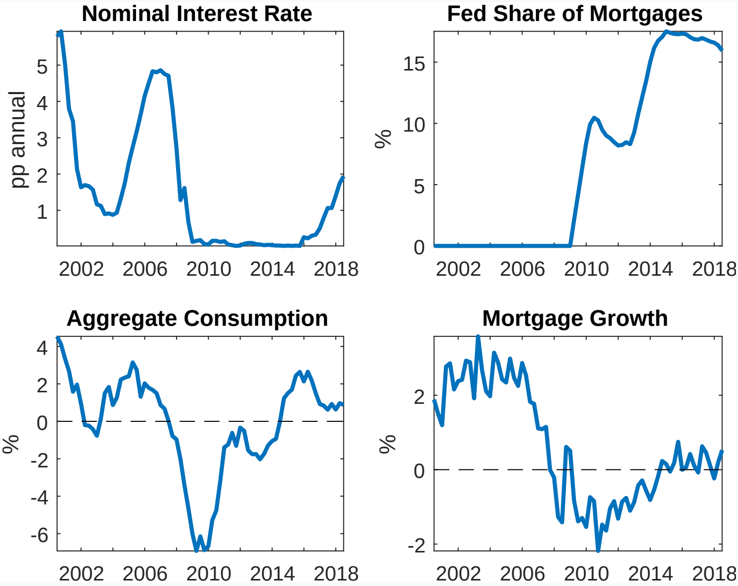
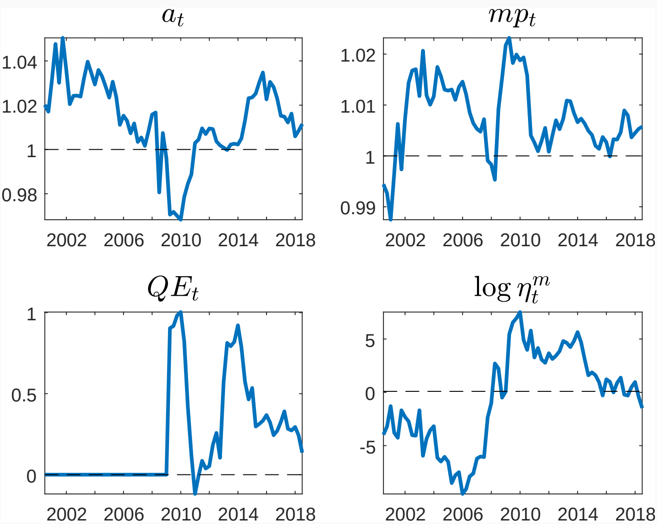
# Data: Observables



# Smoothed Exogenous Processes

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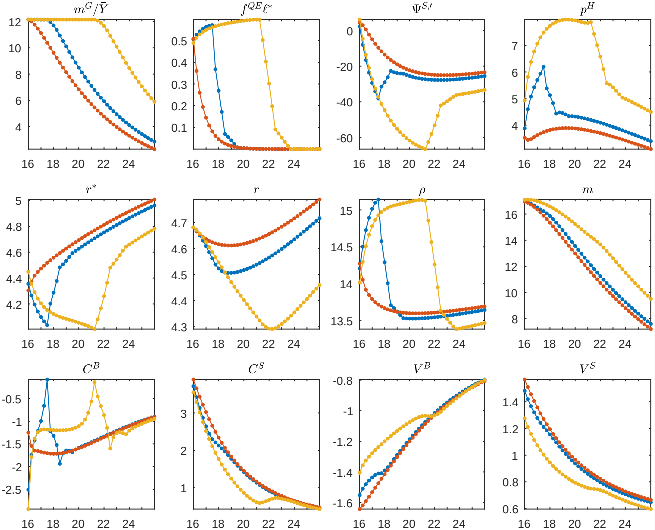
# Policy Normalization

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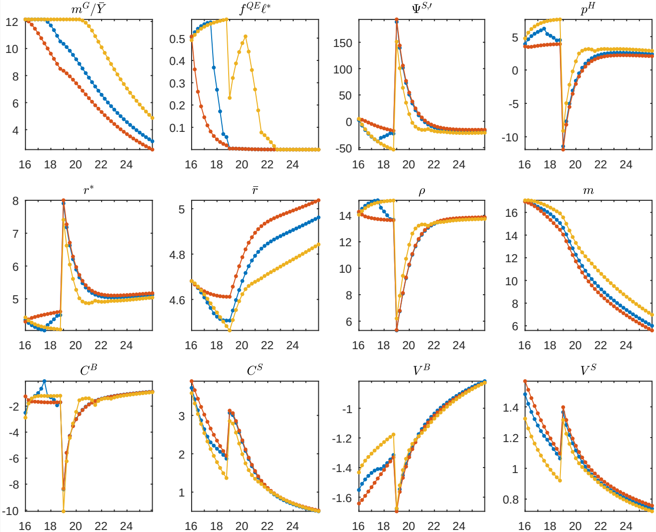
# Policy Normalization: Unexpected Crisis in 2019Q2

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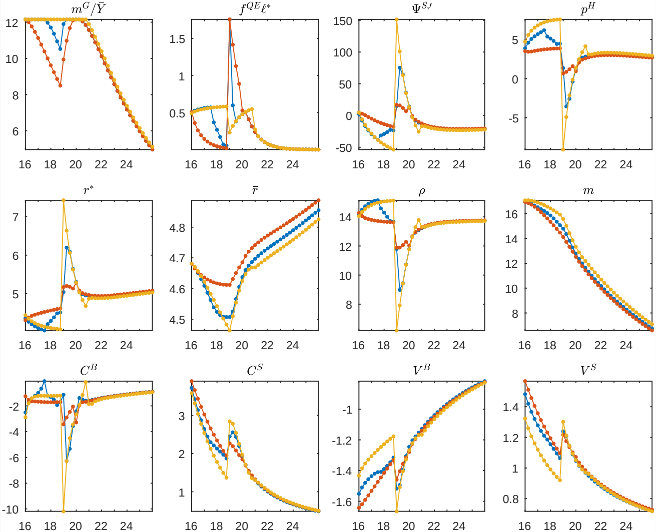
# Policy Normalization: QE4 and Political Constraints

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