Quantitative Tightening with Slow-Moving Capital

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Motivation: from QE to QT

- Central banks in advanced countries are unwinding their bond holdings purchased during QE.
- These Treasury sales (QT) are expected to lower bond prices and raise long-term interest rates.
- Can this happen in a controlled manner symmetric to the QE phase?
  - Would financial frictions that made QE effective backfire during QT and make it ineffective or even destructive?

This Paper

We show that QT could be more than QE in reverse mode, because these policy actions shift the composition of the marginal investors in the Treasury market.

- Empirically, we document new facts about investor composition during the past two QT episodes in 2017–19 and 2022–23.

We classify investors into four categories:

- *Liquidity traders*: brokers and dealers, banks, hedge funds
- *Long-term bond investors*: mutual funds, money market funds, pension funds, ETFs, close-end funds, insurance companies, corporates, and holding companies
- *Rest-of-the-world investors*: foreign official and private holders
- *Federal Reserve*

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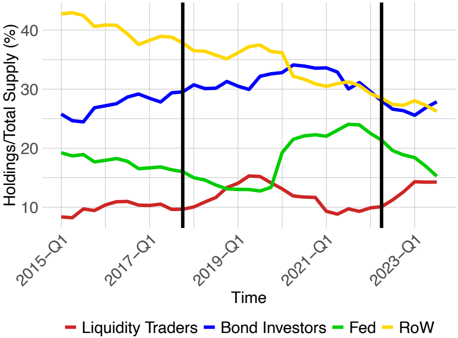
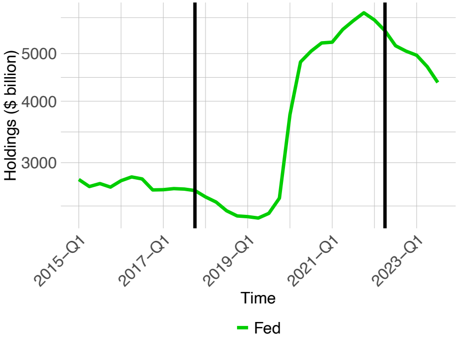
Investor Composition in the Treasury Market



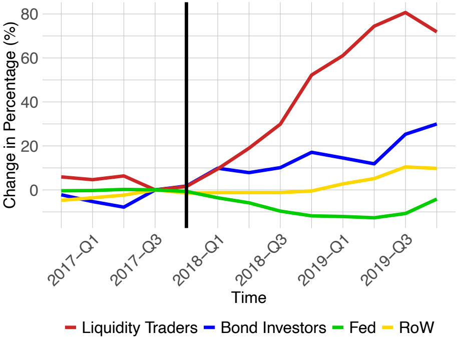
Panel (a) Shares Held by Investor Categories



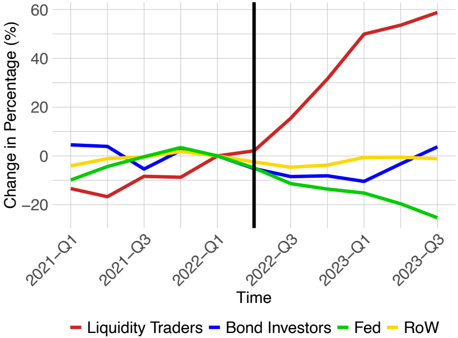
Panel (b) Quantities Held by the Fed

- In QT1, the Fed's holdings ↓ $285 billion from 2017Q3 to 2019Q3, or from 16% to 13% in terms of the share of the total market.
- In QT2, the Fed's holdings ↓ $1,484 billion from 2022Q1 to 2023Q3, or from 22% to 15% in terms of the share of the total market.

Investor Composition around QT Episodes



Panel (a): Changes Relative to 2017 Q3



Panel (b): Changes Relative to 2022 Q1

- Treasury debt sold by the Fed was disproportionately absorbed by liquidity traders.
- Concurrently, from peak to trough 2021–2023, long-term Treasury declined by 40%, an unusually large loss for what is traditionally regarded as a safe and stable market.

This Paper

- Motivated by these facts, we develop a general equilibrium model of bond valuation which highlights the dynamic interaction between heterogeneous investors.
  - Long-term bond investors have higher risk-taking capacity, but face a portfolio adjustment cost.
  - Liquidity traders have lower risk-taking capacity, but can trade freely.
- Equilibrium bond risk premium depends on the composition of the marginal investors, which, in turn, is shaped by the central bank's policy actions.

Model

The Asset Space

Two financial assets

- *the reserve*: a one-period bond with a risk-free interest rate i_t.
  - Perfectly elastic supply.
- *the (long-term) bond* : a perpetual bond that pays a stochastic coupon in each period.
  - coupon x_t with a steady-state value $\bar{x}$, capturing variation in real cash flows
  - ex-coupon price p_t and cum-coupon return $r_{t+1} = \frac{p_{t+1}+x_{t+1}}{p_t}$
  - excess return $er_{t+1} = r_{t+1} - i_t$
  - supply q_t is exogenous

Long-term Bond Investors

- Lower risk aversion γ
- Portfolio return $r^p_{t+1} = i_t + z_t(r_{t+1} - i_t)$.
- Face a portfolio adjustment cost

$$\max_{z_t} \quad \mathbb{E}_t\left[r^p_{t+1}\right] - \frac{1}{2}\gamma \cdot var_t\left(r^p_{t+1}\right) - \frac{1}{2}\mu \cdot c(z_t; z_{t-1}, \bar{z})\sigma_t^2$$
$$c(z_t; z_{t-1}, \bar{z}) = \eta(z_t - \bar{z})^2 + (1-\eta)(z_t - z_{t-1})^2$$

- Optimal portfolio choice:

$$z_t = \frac{\gamma}{\gamma+\mu}\frac{\mathbb{E}_t[er_{t+1}]}{\gamma\sigma_t^2} + \frac{\mu}{\gamma+\mu}(\eta\bar{z} + (1-\eta)z_{t-1})$$

- Bond investors' wealth follows

$$w_t = (1-\phi)w^e + \phi\left(w_{t-1}r^p_t\right)$$

Liquidity Traders

- Higher risk aversion $\omega > \gamma$
- Portfolio return $r^{\ell}_{t+1} = \ell_t(r_{t+1} - i_t)$
- Can trade freely without adjustment cost

$$\max_{\ell_t} \quad \mathbb{E}_t\left[r^{\ell}_{t+1}\right] - \frac{1}{2}\omega \cdot var_t\left(r^{\ell}_{t+1}\right)$$

- Optimal portfolio choice:

$$\ell_t = \frac{\mathbb{E}_t[er_{t+1}]}{\omega\sigma_t^2}$$

- Key intuition: liquidity traders require a higher risk premium if they need to hold more bonds.

Market Clearing & Model Summary

- The market clearing condition for the bond is,

$$w_t z_t + m\ell_t = q_t p_t.$$

- The (short-term) reserve has elastic supply at exogenous interest rate i_t.
- We assume exogenous variables all follow AR(1) processes:

$$\log x_{t+1} = (1-\theta_x)\log \bar{x} + \theta_x \log x_t + \sigma_x \varepsilon_{x,t+1},$$
$$\log q_{t+1} = (1-\theta_q)\log \bar{q} + \theta_q \log q_t + \sigma_q \varepsilon_{q,t+1},$$
$$\log i_{t+1} = (1-\theta_i)\log \bar{i} + \theta_i \log i_t + \sigma_i \varepsilon_{i,t+1}.$$

Model Summary

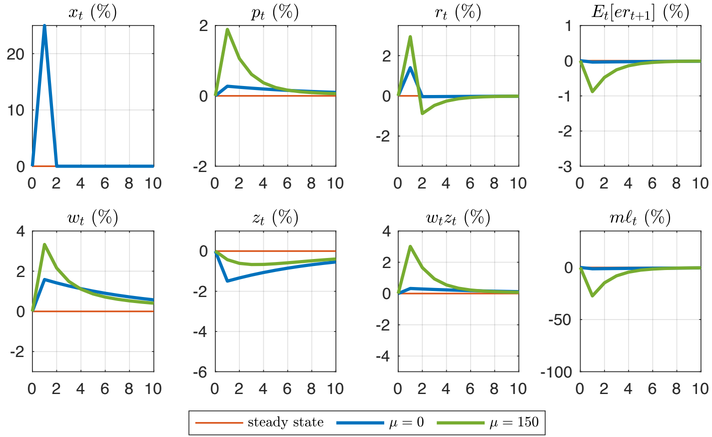
- After log-linearization, we can describe the model using the following forward-looking system of linear equations.

$$
\begin{aligned}
&\text{(Campbell-Shiller)} \quad \hat{r}_t = \kappa_1 \hat{p}_t - \hat{p}_{t-1} + (1-\kappa_1)\hat{x}_t \\
&\text{(Market Clearing)} \quad \hat{p}_t + \hat{q}_t = \frac{\bar{w}\bar{z}}{\bar{p}\bar{q}}\left(\hat{w}_t + \frac{1}{\bar{z}}\hat{z}_t\right) + \frac{m\bar{\ell}}{\bar{p}\bar{q}}\left(\frac{1}{\bar{\ell}}\hat{\ell}_t\right) \\
&\text{(Wealth Dynamics)} \; \hat{w}_t = \bar{r}^p \phi \hat{w}_{t-1} + \bar{r}^p \phi \left(\hat{i}_{t-1} + \bar{z}\left(\hat{r}_t - \hat{i}_{t-1}\right) + \hat{z}_{t-1}(\hat{r}_t - \hat{i}_{t-1} + \log \bar{r} - \log \bar{i})\right) \\
&\text{(Portfolio Choice)} \quad \hat{z}_t = \frac{\mu}{\gamma+\mu}(1-\eta)\hat{z}_{t-1} + \frac{\gamma}{\gamma+\mu}\frac{1}{\bar{\sigma}^2\gamma}\mathbb{E}_t[\hat{r}_{t+1} - \hat{i}_t] \\
&\text{(Portfolio Choice)} \quad \hat{\ell}_t = \frac{1}{\bar{\sigma}^2\omega}\mathbb{E}_t[\hat{r}_{t+1} - \hat{i}_t]
\end{aligned}
$$

- Easy plug-in for DSGE frameworks.

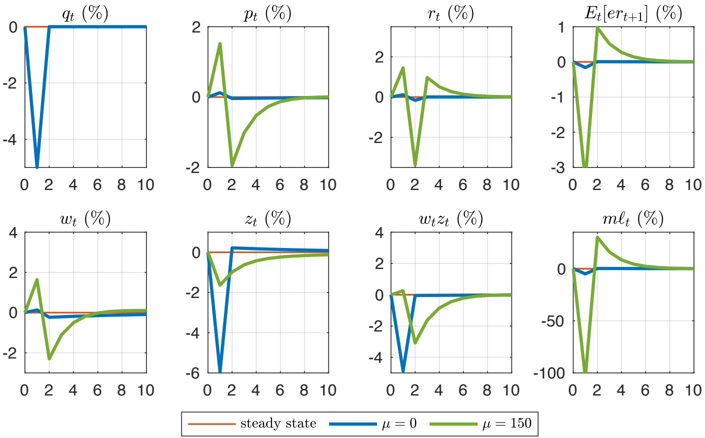
Results

Impulse Response to a Transitory Cash Flow Shock



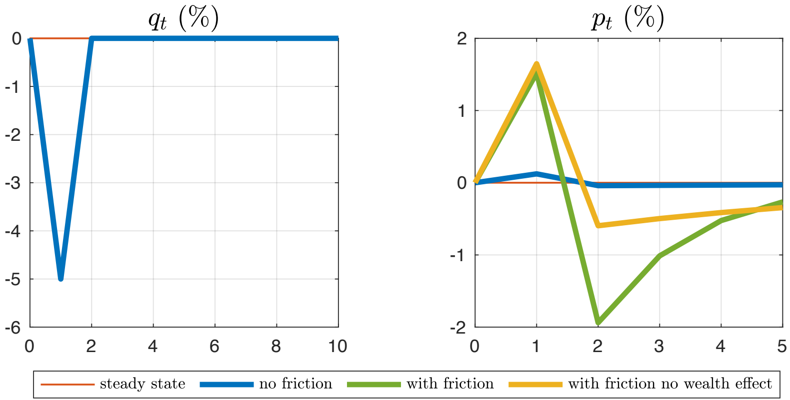
- The cash flow shock makes the bond investors wealthier.
- The cash flow shock is doubly good news as it also lowers the discount rate.
- Slow portfolio adjustment increases price volatility.

Impulse Response to a Transitory Supply Shock



- The portfolio friction generates inelastic bond demand and Dornbusch [1976] style overshooting
- Subsequent price reversal can be bigger than the initial price increase due to forward-looking price

The Role of Investor Wealth



- The wealth effect reduces the bond investors' risk-taking capacity and their demand for the bond, which further lowers the bond price during the QT.

Model Also Matches Relevant Bond Pricing Moments

Panel (b) Implied Steady-State Values			
Bond investor's leverage	$\bar{z}$	119.03%	
Expected excess return of bonds	$\bar{er}$	3.11%	3.07%
Bond yield spread	$\bar{y} - \bar{i}$	3.20%	2.15%
Bond Sharpe ratio	$\bar{er}/\bar{\sigma}$	0.27	0.26

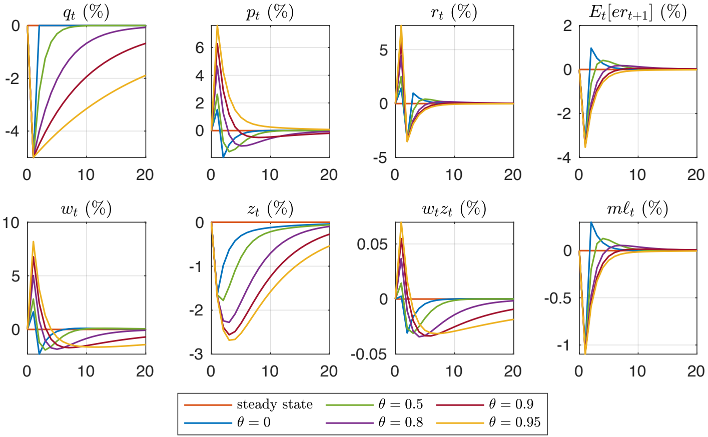
Model Also Matches Relevant Bond Pricing Moments

Moments	(1) x Shock	(2) q Shock	(3) i Shock	(4) All Shocks	(5) Data
Panel A: Model with no transaction cost $\mu = 0$:					
Vol(er_t) (%)	4.08	0.40	2.23	4.65	11.63
Autocorr(er_t)	−0.01	−0.16	−0.00	−0.01	0.05
Vol(i_t) (%)	0.00	0.00	1.11	1.11	1.11
β_{IE}	−0.00	−0.00	0.35	0.33	0.44
β_{RP}	0.72	8.69	0.00	0.05	1.76
Panel B: Model with transaction cost $\mu = 150$					
Vol(er_t) (%)	7.38	5.14	2.05	9.18	11.63
Autocorr(er_t)	−0.09	−0.27	−0.02	−0.14	0.05
Vol(i_t) (%)	0.00	0.00	1.11	1.11	1.11
β_{IE}	0.00	−0.00	0.34	0.27	0.44
β_{RP}	3.59	13.94	0.03	1.21	1.76

- Regression 1: $i_{t+1} - i_t = \alpha_{IE} + \beta_{IE}\,(y_t - i_t) + u_{IE,t+1}$.
- Regression 2: $er_{t+1} = r_{t+1} - i_t = \alpha_{RP} + \beta_{RP}\,(y_t - i_t) + u_{RP,t+1}$.

Simulated Moments with Transitory Shocks

Gradual Tightening



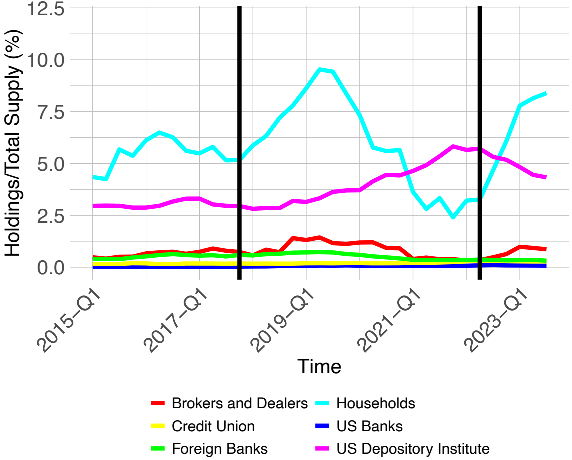
- More gradual QT: gives long-term investors more time to adjust their holdings, avoids bond price crash
- Not a free lunch: persistently lower wealth for LT investors as bond returns are depressed

Conclusion

- We document major changes in investor composition in the Treasury market during quantitative tightening (QT).
- Develop an equilibrium model of bond valuation that emphasizes the dynamic interaction between heterogeneous investors.
- Due to portfolio friction, QT is not simply QE in reverse mode: an overshooting effect that negatively impacts the bond price.
- Investor wealth loss magnifies the bond price response.
- A dynamic account of the bond market crash in the 2022–23 QT episode: selling 7% of total quantity implies a price decline of 5%.

Appendix

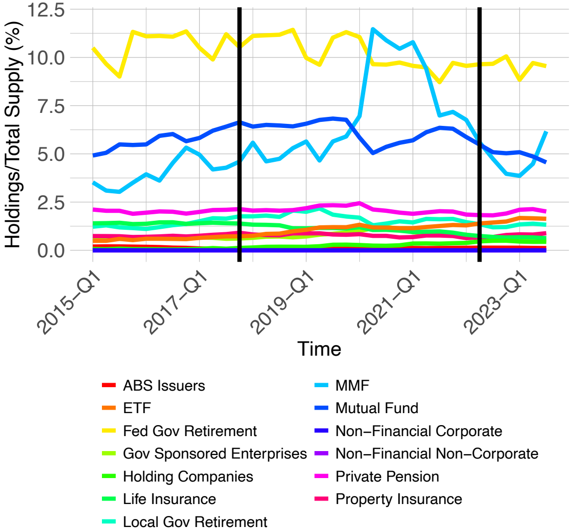
Liquidity Traders



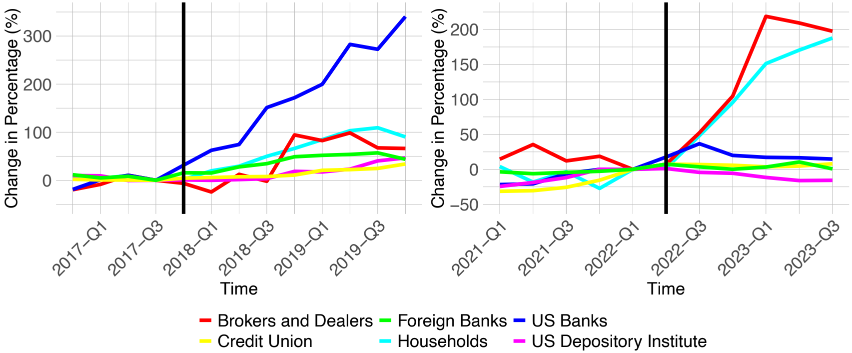
- Banegas et al. [2021]: household sector includes domestic hedge funds.

Hedge Funds | Households Sector

Bond Investors

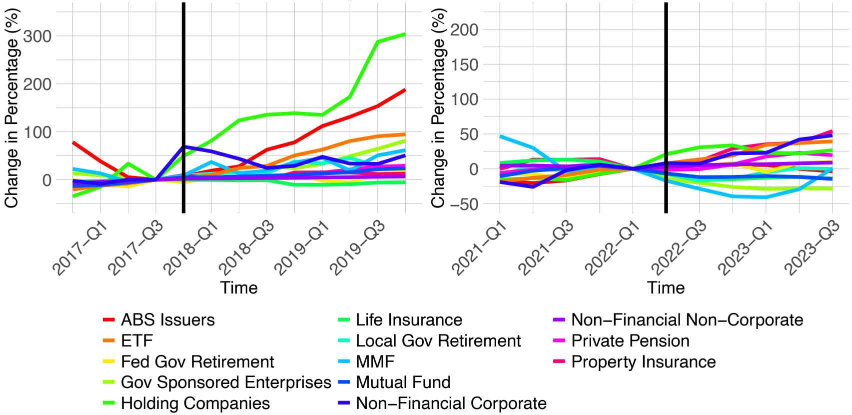


Liquidity Traders Composition around QT Periods



- During QT1, US banks exhibited the most significant reaction, although their absolute holdings were relatively small.
- During QT2, brokers and dealers and households experienced the most significant increases in their holdings.

Bond Investors Composition around QT Periods

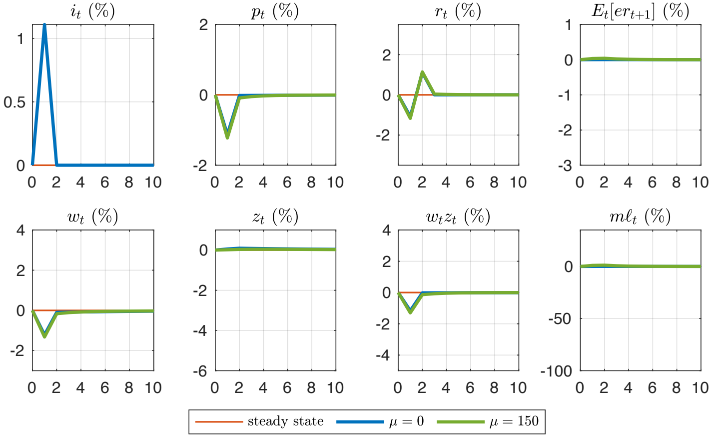


- During QT1, holding companies, ABS issuers, and ETFs experienced the most significant increases in their Treasury holdings but the absolute sizes were relatively small.
- During QT2, bond investors responded quite diversely.

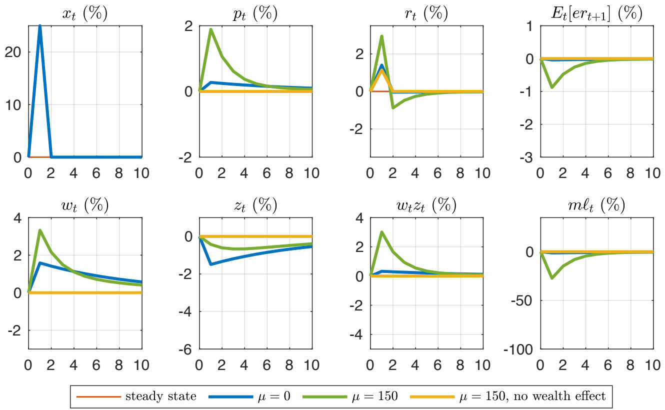
Model Parameters

Panel (a) Parameters			
Interpretation	Symbol	Parameter Value	Empirical Moment
Bond Investor-Side Parameters:			
Risk-aversion coefficient	γ	2	
Steady-state wealth	$\bar{w}$	90	
Wealth replenishment rate	ϕ	0.90	
Portfolio adjustment penalty	μ	150	
Benchmark deviation penalty	η	0.1	
Liquidity Trader-Side Parameters:			
Risk-aversion coefficient	ω	6	
Mass	m	10	
Asset-Side Parameters:			
Steady-state bond quantity	$\bar{q}$	100	
Steady-state interest rate	$\bar{i}-1$	1.56%	1.56%
Steady-state coupon	$\bar{x}$	5.31%	5.31%
Bond return volatility	$\bar{\sigma}$	11.64%	11.64%
Interest rate volatility	σ_i	1.11%	1.11%
Bond quantity volatility	σ_q	5%	
Coupon volatility	σ_x	25%	

Impulse Response to a Transitory Interest Rate Shock

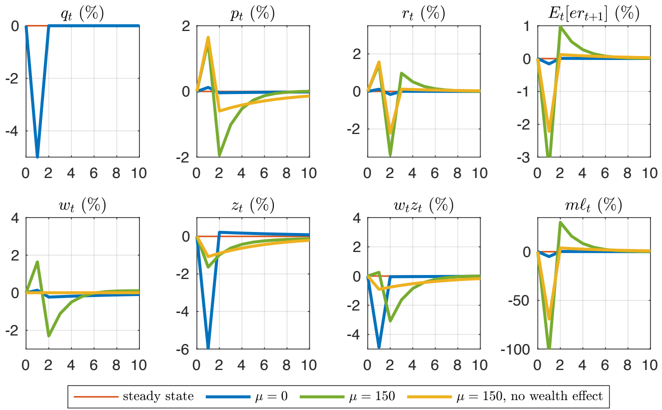


Impulse Response to a Transitory Cash Flow Shock



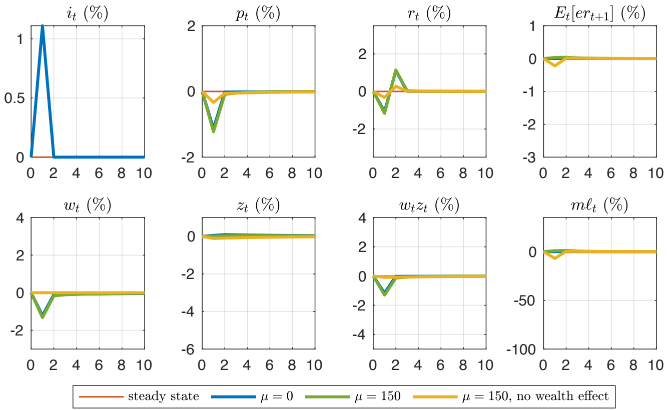
- The discount rate effect we found is entirely due to the effect of the cash flow shock on the bond investors' wealth.

Impulse Response to a Transitory Supply Shock



- In period 2, bond investors have more wealth to hold more bond positions, and liquidity traders need to absorb a lower quantity of bonds sold by bond investors.

Impulse Response to a Transitory Interest Rate Shock



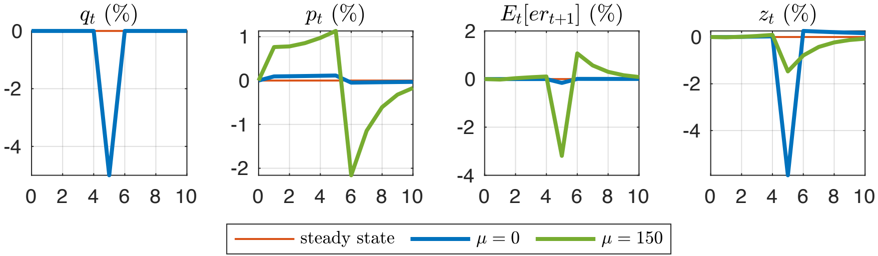
- In period 1, if bond investors have a constant level of wealth, they can adjust their portfolio to hold more bonds, and liquidity traders need to sell some bonds to meet the increased demand from bond investors.

Simulated Moments with Transitory Shocks ($\theta = 0$)

Moments	x Shock	q Shock	i Shock	All Shocks	Data
Panel A: Model with no transaction cost $\mu = 0$:					
Vol(er_t) (%)	1.41	0.20	1.08	1.78	11.63
Autocorr(er_t)	−0.02	−0.49	−0.00	−0.02	0.05
Vol(i_t) (%)	0.00	0.00	1.11	1.11	1.11
β_{IE}	−0.00	−0.00	1.05	1.05	0.44
β_{RP}	3.11	18.97	−0.00	0.00	1.76
Panel B: Model with transaction cost $\mu = 150$					
Vol(er_t) (%)	3.14	3.86	1.18	5.09	11.63
Autocorr(er_t)	−0.20	−0.50	−0.03	−0.37	0.05
Vol(i_t) (%)	0.00	0.00	1.11	1.11	1.11
β_{IE}	−0.00	−0.00	1.05	1.03	0.44
β_{RP}	9.48	21.58	−0.03	0.41	1.76

- Regression 1: $i_{t+1} - i_t = \alpha_{IE} + \beta_{IE}\left(y_t - i_t\right) + u_{IE,t+1}$.
- Regression 2: $er_{t+1} = r_{t+1} - i_t = \alpha_{RP} + \beta_{RP}\left(y_t - i_t\right) + u_{RP,t+1}$.

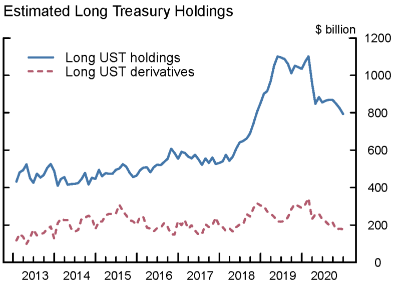
Impulse Responses to Shocks to Expected Bond Supply

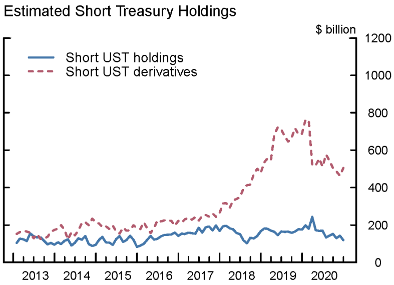


- Announcements of central bank bond purchases can also support the bond price up front.
- Period 6: Bond investors are unable to gradually adjust their portfolios ahead of scheduled central bank bond sale, despite having prior knowledge of them.

Full Impulse Responses

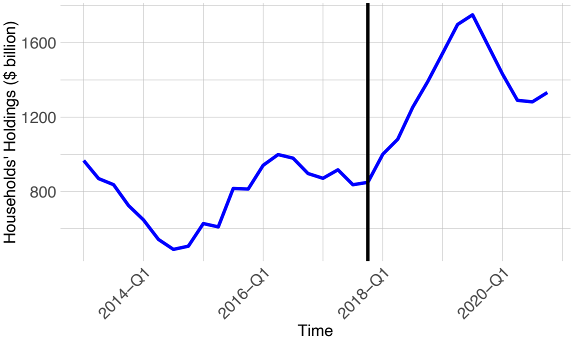
Hedge Funds' US Treasury Holdings





Notes: This figure refers to Figure 6 of Banegas et al. [2021], which reports the estimated long and short Treasury holdings and derivatives positions of qualifying hedge funds.

Households' US Treasury Holdings



Notes: This figure reports the level of households' treasury holdings. The vertical black line marks the beginning of the first QT.