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The Contribution of Foreign Holdings of U.S. Treasury Securities to the U.S. Long-Term Interest Rate

An Empirical Investigation of the Impact of the Zero-Lower Bound

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The views expressed in this presentation are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Dallas or the Federal Reserve System.

Outline

- Some background and motivation
  - Brief literature review
- Data and key findings
  - Connecting the dots
  - Data exploration and methodological approach
  - Evidence of structural break, shifting impacts
- Understanding the implications for U.S. long-term yields
  - Effects of QE (and of its removal)
  - China's role
- Concluding remarks

Some Background and Motivation

Literature Review

- Numerous studies quantify the negative relationship between foreign holdings (or net purchases) of U.S. Treasuries and U.S. long-term yields
  - Flows: Rudebusch et al. (2006), Warnock and Warnock (2009), Beltran et al. (2013)
  - Stocks: Craine and Martin (2009), Bandholz et al. (2009), Bertaut et al. (2012), Beltran et al. (2013), Kaminska and Zinna (2014)
- Many related studies have investigated the same relationship for other countries
  - Euro area: Carvalho and Fidora (2015)
  - Advanced economies: Andritzky (2012), Arslanalp and Poghosyan (2014)
  - Emerging economies: Peiris (2010), Pradhan et al. (2011), and Ebeke and Lu (2014)
- Most of these papers largely rely on linear specifications that keep the marginal effects constant over time

Parameter Instability

- Restricting sample periods (particularly to avoid the 2008-09 financial crisis)
  - Beltran et al. (2013), Goda et al. (2013)
- Documenting variation in the relationship across sub-samples
  - Wu (2005), Briere et al. (2008)
- Documenting variation in the estimated marginal effects across sub-samples
  - Mann and Klachkin (2012), Beltran et al. (2013)
  - Kaminska and Zinna (2014)

- Extending the Warnock and Warnock (2009) model from 1986m01 to 2014m12, we find compelling evidence of parameter instability with the recursive residuals, CUSUM and CUSUM of square test statistics.

Our Contribution to the Literature

- The paper explores the role of foreign demand of U.S. bonds and Treasuries on the U.S. long-term interest rate
- A one percentage point increase (decrease) in the foreign official holdings ratio has an overall impact of:
  - reducing (raising) the long-term interest rate by around 6 basis points at the ZLB period
  - …compared to 4 basis points in the pre-ZLB period
- The paper provides empirical evidence suggesting that the zero-lower bound can be a leading cause for this structural break in the relationship

A Stylized Model of the Term Structure of Interest Rates

Connecting the Dots…

- A benchmark model of the term structure of interest rates motivating the error-correction specification commonly used in the literature:

$$i_{n,t} = \frac{1}{n}\left[\sum_{j=1}^{n} E_t(i_{1,t+j-1})\right] + \theta_{n,t}, \text{ (Weak form expectations hypothesis)}$$

$$i_{1,t} = r_{1,t} + E_t(\pi_{t+1}), \qquad \text{(Fisher equation)}$$

$$\theta_{n,t} = \theta_n^0 + \theta_n^1 fh_t + \theta_n^2 \varepsilon_{n,t}, \qquad \text{(Time-varying premia)}$$

fh_t is the foreign holdings of U.S. Treasury securities as a percentage of outstanding marketable Treasury securities (net of Federal Reserve holdings)

- We combine these economic relationships to obtain

$$\left(i_{n,t} - \pi_{t,n}^e\right) - \left(i_{1,t} - \pi_{t,1}^e\right) - \theta_n^1 fh_t = \frac{1}{n}\left[\sum_{j=1}^{n} E_t\left(r_{1,t+j-1}\right)\right] - r_{1,t} + \theta_n^0 + \theta_n^2 \varepsilon_{n,t}$$

$$= \sum_{j=1}^{n-1}\left(1 - \frac{j}{n}\right) E_t\left(\Delta r_{1,t+j}\right) + \theta_n^0 + \theta_n^2 \varepsilon_{n,t},$$

where $\pi_{t,1}^e \equiv E_t(\pi_{t+1})$ and $\pi_{t,n}^e \equiv \frac{1}{n}\left[\sum_{j=1}^{n} E_t\left(\pi_{t+j}\right)\right]$.

A Key Cointegrating Relationship

Single-Equation Error Correction Model (SEECM)

- Whenever $i_{n,t} \sim I(1)$, $i_{1,t} \sim I(1)$, $\pi^e_{t,n} \sim I(1)$, $\pi^e_{t,1} \sim I(1)$, and $fh_t \sim I(1)$, the variables are cointegrated up to a constant if:
  - The short-term real interest rate is $r_{1,t} \sim I(1)$—and hence $\Delta r_{1,t} \sim I(0)$—and the exogenous component of the premia is $\varepsilon_{n,t} \sim I(0)$.
  - Because then, the left-hand side term of the previous equation must be stationary.
- According to the Granger representation theorem in Engle and Granger (1987), there exists a vector error correction representation
- The single-equation error correction model (e.g., Warnock and Warnock (2009)) can be expressed as,

$$\Delta i_{n,t} = \beta_0 + \alpha(\gamma' X_{t-1}) + \sum_{l=1}^{k} \beta_l' \Delta X_{t-l} + e_t, \qquad \text{(SEECM)}$$

where $X_t = (i_{n,t}, i_{1,t}, \pi^e_{t,n}, \pi^e_{t,1}, fh_t)'$.

Modeling the Zero-Lower Bound (ZLB)

- We build on Black (1995)'s interest rate model — The ZLB constraint arises because the existence of zero-interest-bearing cash (currency) implies nominal interest rates on bonds must be non-negative to rule out arbitrage.
- A latent relationship for the shadow rate $i_{1,t}^{*}$ and an observation equation $i_{1,t}$ for the nominal interest rate given as follows,

$$i_{1,t}^{*} = z_t'\alpha + u_t^2, \qquad \text{(Latent)}$$

$$i_{1,t} = \begin{cases} 0 \quad if\ z_t'\gamma + u_t^1 \leq 0\ (ZLB), \\ i_{1,t}^{*}\ if\ z_t'\gamma + u_t^1 > 0\ (Non - ZLB), \end{cases} \qquad \text{(Observed)}$$

where $\Phi\left(\frac{z_t'\gamma}{\sigma_1}\right)$ is the likelihood of hitting the ZLB.

- We adopt Heckman selection procedure to recover the shadow rate $i_{1,t}^{*}$ with z_t' including inflation and the output gap as in a conventional Taylor (1993) rule

Revisiting the SEECM with the ZLB

- The weak form of the expectations hypothesis can be generalized as,

$$i_{1,t} = \max\{i^*_{1,t}, 0\} = i^*_{1,t} + \max\{-i^*_{1,t}, 0\}$$

$$i_{n,t} = \frac{1}{n}\left[\sum_{j=1}^{n} E_t(\max\{i^*_{1,t+j-1}, 0\})\right] = \frac{1}{n}\left[\sum_{j=1}^{n} E_t(i^*_{1,t+j-1})\right] + l_{n,t} + \theta_{n,t}$$

  where $l_{n,t} \equiv \frac{1}{n}\left[\sum_{j=1}^{n} E_t(\max\{-i^*_{1,t+j-1}, 0\})\right]$ defines the option-like floor value of the short-term interest rate (an additional premium).

- The shadow rate $i^*_{1,t}$ should enter instead $i_{1,t}$ into (SEECM). The option-like floor value $l_{n,t}$ is a (possibly nonlinear) function of the latent rate $i^*_{1,t}$.
- Away from the ZLB, the latent and observed rates coincide and $l_{n,t}$ may even be negligible
  - Near or at the ZLB, the same does no longer hold true – introducing omitted variables bias in the cointegrating relationship linking long- and short-term rates.

Data and Key Findings

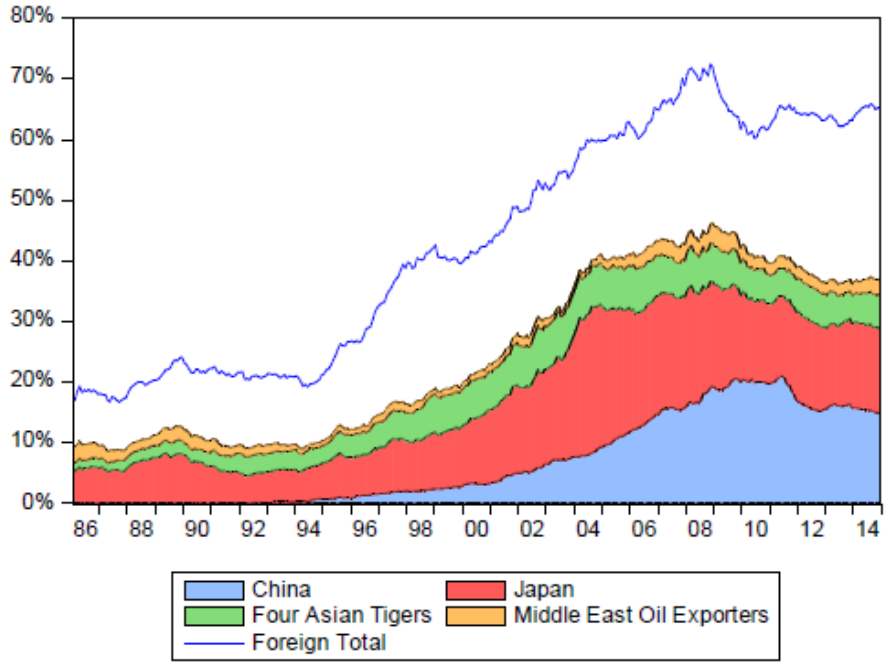
Data: Foreign Holdings

- Our key measure of foreign holdings is the ratio of foreign official holdings of U.S. long-term Treasury securities as a share of marketable Treasury notes and bonds (total outstanding U.S. Treasuries excluding the Federal Reserve's holdings).
  - Bertaut and Tryon (2007), Bertaut and Judson (2014) -- with total outstanding Treasury notes and bonds data obtained from the Monthly Statement of the Public Debt (MSPD) of the Department of the Treasury and with the Federal Reserve's holdings of U.S. Treasury notes and bonds data available in the Federal Reserve's statistical release H.4.1.
- The foreign official holdings ratio increased from around 11% in early 1994 to 56% at the end of 2008.

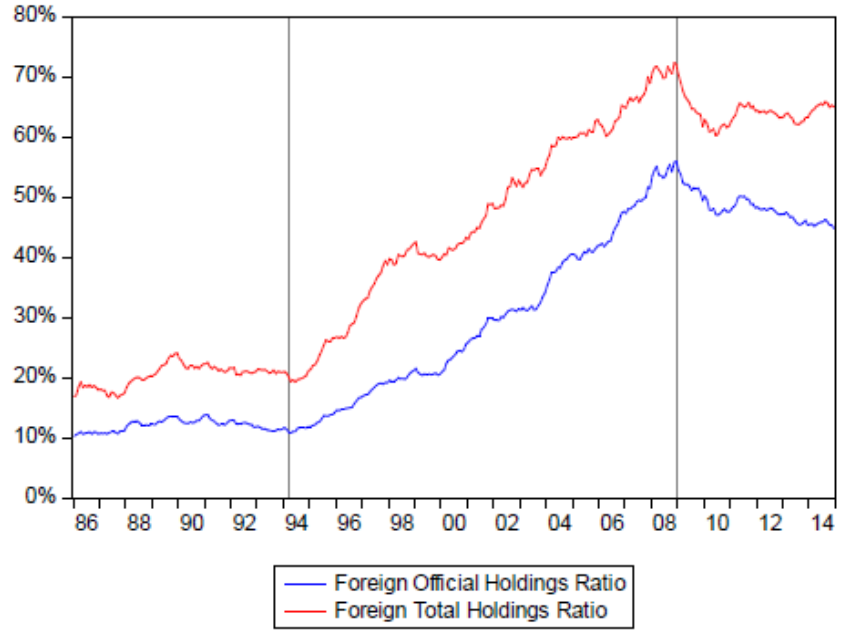
Data: Foreign Holdings

- Foreign Total Holdings of U.S. Long-Term Treasury Securities as a Share of Outstanding Marketable Treasury Notes and Bonds

A. By Different Foreign Holders



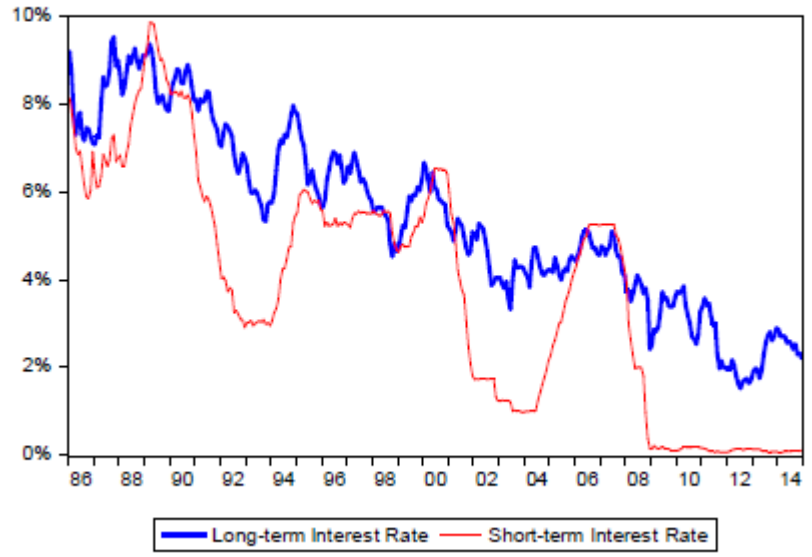
B. By Ownership Type: Total Holdings vs. Official-Only Holdings



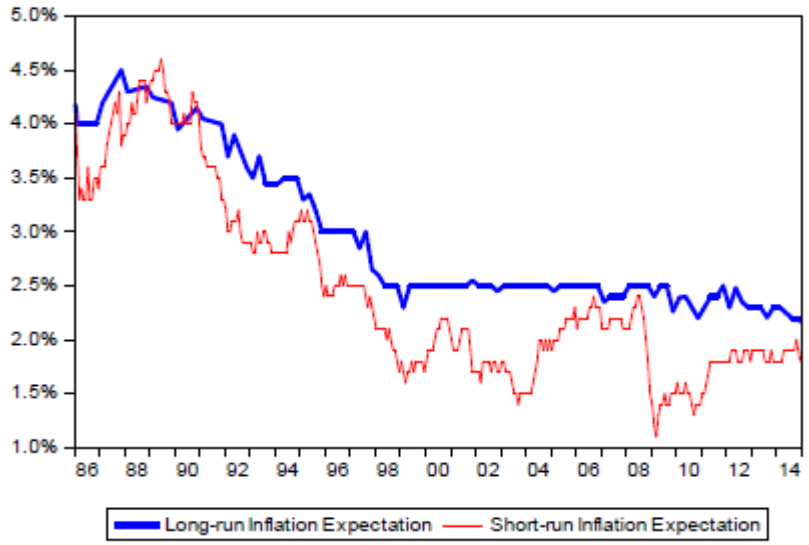
Data: Other Variables

- Other key data series: FRED Database, Survey of Professional Forecasters (SPF), Blue Chip Economic Indicators.

A. Long-term and Short-term Interest Rates



B. Long-run and Short-run Inflation Expectation



Evidence of Shifting Impacts

- Unit root tests (ADF) suggest variables $i_{n,t}$, $i_{1,t}$, $\pi^e_{t,n}$, $\pi^e_{t,1}$ and fh_t are I(1) over the full sample period between 1986m01 and 2014m12

$$i_{n,t} = \gamma_0 + \gamma_1 i_{1,t} + \gamma_2 \pi^e_{t,n} + \gamma_3 \pi^e_{t,1} + \gamma_4 fh_t + \varepsilon_t, \quad \text{(Long-run cointegrating relation)}$$

- A battery of tests—the Hao and Inder (1996) FMOLS-based CUSUM test, Hansen (1992)'s instability tests, and Gregory and Hansen (1996)'s no-cointegration tests with a single structural break—suggest a break around 2008.
- Linear vs. Threshold ECM

$$\Delta i_{n,t}$$
$$= \beta_0 + \alpha\left(i_{n,t-1} - \gamma_1 i_{1,t-1} - \gamma_2 \pi^e_{t-1,n} - \gamma_3 \pi^e_{t-1,1} - \gamma_4 fh_{t-1} d_t - \bar{\gamma}_4 fh_{t-1}(1-d_t)\right) + \cdots$$
$$\beta_1 \Delta i_{n,t-1} + \beta_2 \Delta i_{1,t-1} + \beta_3 \Delta \pi^e_{t-1,n} + \beta_4 \Delta \pi^e_{t-1,1} + \beta_5 \Delta fh_{t-1} d_t + \bar{\beta}_5 \Delta fh_{t-1}(1-d_t) + \varepsilon_t$$

where $d_t = 0$ if $(i_{1,t-1} + i_{1,t-2})/2 \geq \tau$, $d_t = 1$ if $(i_{1,t-1} + i_{1,t-2})/2 < \tau$.

Linear vs. Threshold Error-Correction Model

	(1)	(4)	(7)
	1986m01–2008m11	1986m01–2014m12	1986m01–2014m12
α	-0.136***	-0.113***	-0.120***
$i_{1,t-1}$	0.248***	0.339***	0.259***
$\pi^{e}_{t-1,n}$	1	1	1
$\pi^{e}_{t-1,1}$	-0.248***	-0.339***	-0.259***
fh_{t-1}	-0.046***	-0.050***	
$fh_{t-1}d_t$			-0.061***
$fh_{t-1}(1-d_t)$			-0.044***

Similar split found with the smooth transition regression (STR) specification

Note: ***, ** and * represent the level of significance at 1%, 5% and 10%, respectively. Columns (1) to (3) use the linear SEECM specification for the subsample 1986m01 – 2008m11. Columns (4) to (6) use the linear SEECM specification for the full sample 1986m01 – 2014m12. Column (7) uses the threshold SEECM specification for the full sample 1986m01 – 2014m12.

Threshold ECM: Actual vs. Shadow Federal Funds Rate

Federal funds rate (FFR)	Estimated coefficients on foreign official holdings ratio				Wald Test of the equivalence of long-run coefficients (P-Values)
	Short-run		Long-run		
	Pre-ZLB period	ZLB period	Pre-ZLB period	ZLB period	
Actual FFR	-0.048	-0.138***	-0.044***	-0.061***	0.05
Wu-Xia Shadow FFR	-0.048	-0.129***	-0.045***	-0.055***	0.28
Krippner Shadow FFR	-0.044	-0.131***	-0.047***	-0.052***	0.53
Heckman Selection Shadow FFR	-0.043	-0.130***	-0.049***	-0.052***	0.78

Note: ***, ** and * represent the level of significance at 1%, 5% and 10%, respectively.

We cannot reject the hypothesis that the long-run coefficients are the same

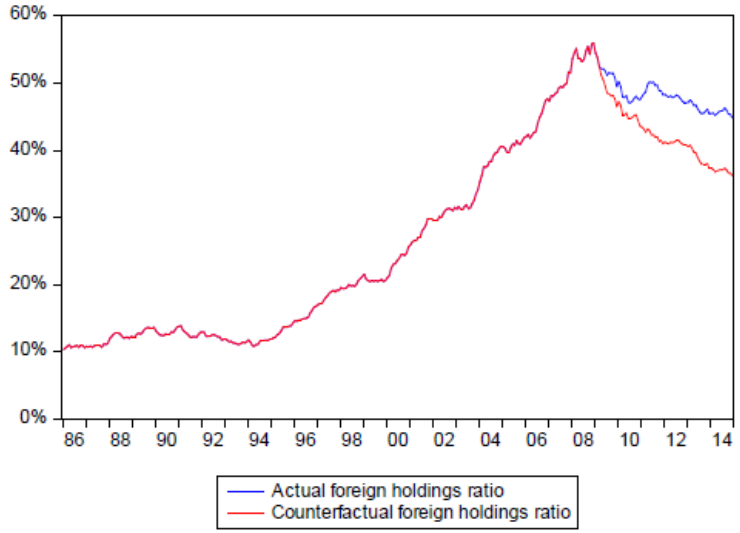
Robustness checks

- Following Norrbin et al. (1997), we test the weak exogeneity of the foreign official holdings ratio. We deal with endogeneity with a VECM model of the foreign official holdings ratio, the short-term and long-term rate, and the long-run and short-run inflation expectations.
  - The evidence suggests that the disequilibrium from the long-run cointegrating relationship can only be adjusted through the long-term interest rates.
- Threshold ECM model results are robust to the inclusion of additional controls.
  - We consider the following control variables: the log of S&P 500 index (sp_t), U.S. budget deficit scaled by GDP (def_t), expected real GDP growth over the next year ($growth_t$), and the log of VXO index (vxo_t).
- Threshold ECM model results are robust to using total foreign holdings, not just official holdings.

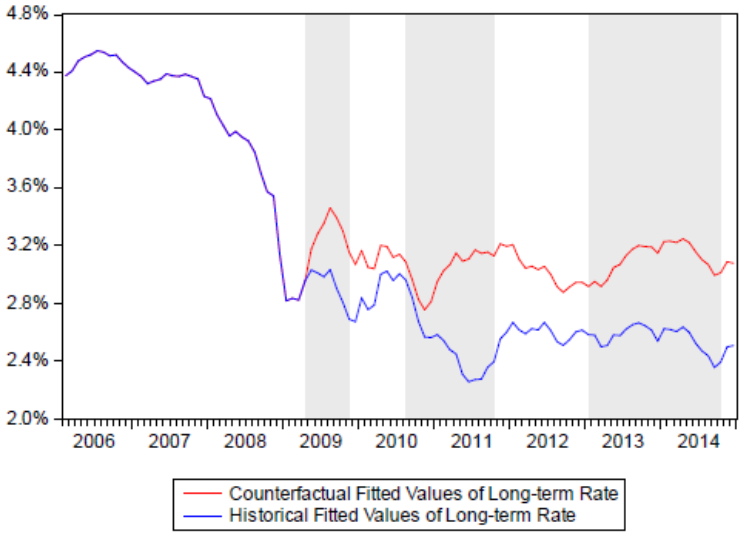
Understanding the Implications for U.S. Long-Term Yields

Effects of Quantitative Easing (QE)

A. Actual and Counterfactual Foreign Official Holdings Ratio



B. Enlarged View of the Fitted Values of the Long-Term Interest Rate

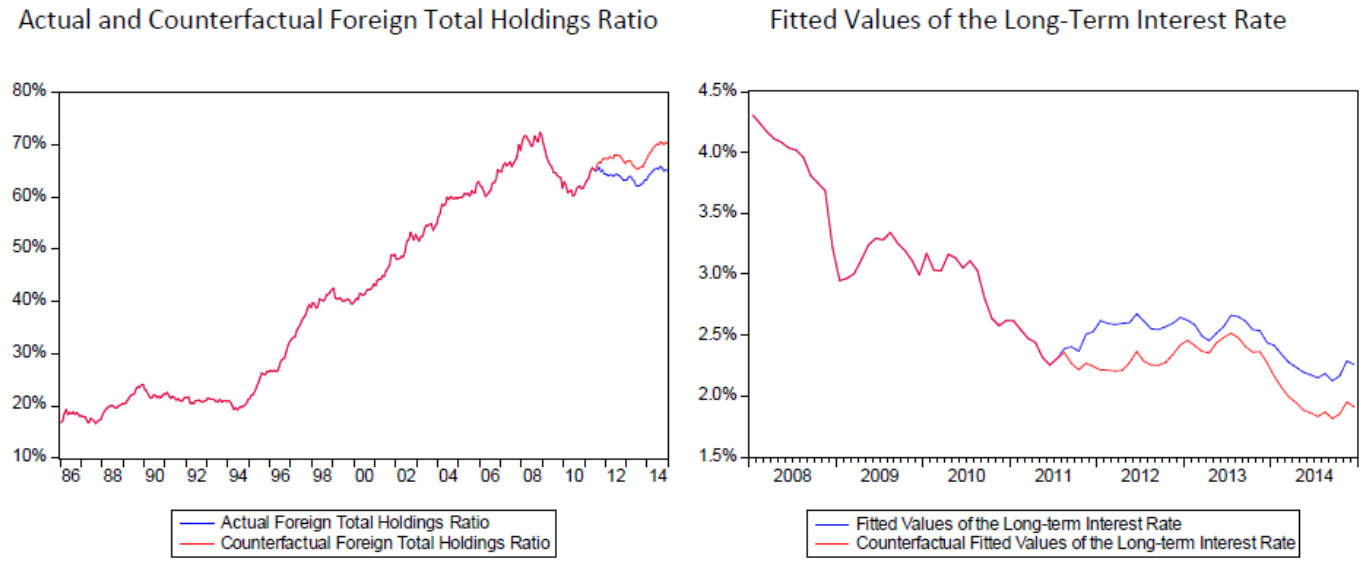


Sources: Bertaut and Tryon (2007), Bertaut and Judson (2014), FRB H.4.1., Department of the Treasury, and authors' calculations based on our benchmark empirical model.

Note: We compute the foreign official holdings ratio as foreign official holdings of U.S. Treasury notes and bonds divided by the outstanding U.S. Treasury notes and bonds excluding Fed's holdings. We construct the counterfactual foreign official holdings ratio by assuming that Fed's holdings kept at the level of 2009m03 for the remaining period of our sample.

China's Unwinding Reserves (2011-14)

Panel B: China's unwinding-of-Treasuries period (2011-14)



Sources: Bertaut and Tryon (2007), Bertaut and Judson (2014), FRB H.4.1., Department of the Treasury, and authors' calculations based on our benchmark empirical model.

Note: the counterfactual foreign total holdings are the sum of the counterfactual China's holdings and the actual holdings of other foreign countries. In Panel A, the counterfactual of China's holdings is calculated by assuming the growth of China's holdings from 2001m01 to 2006m12 had kept at the same pace as in the period from 1994m01 to 2000m12. In Panel B, the counterfactual of China's holdings is calculated by assuming the growth of China's holdings from 2011m07 to 2014m12 had kept at the same pace as in the period from 2001m01 to 2011m06.

Concluding Remarks

Concluding Remarks

- The evidence suggests to us that the foreign demand of Treasury notes and bonds is an economically important factor driving the U.S. long-term yield…
  - …although its role is significantly influenced by the ZLB.
- Our results provide a quantitative assessment of the economic impact of the different rounds of QE on lowering the long-term yield:
  - QE may have lowered the long-term yield by 38 to 55 basis points on average.
- We also find that the unwinding in China's holdings of Treasuries that started in 2011m07 kept the U.S. long-term yield 25 basis points higher on average than otherwise.

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Check out the working paper here:

SSRN WP #3495790: https://papers.ssrn.com/abstract=3495790

Appendix: Conditional Expectations

- Conditional on a sub-sample where interest rates are away from the ZLB

$$E\left(i_{1,t}\middle|z_t, z_t'\gamma + u_t^1 > 0\right) = z_t'\alpha + \sigma\lambda\left(\frac{z_t'\gamma}{\sigma_1}\right)$$

- For the full sample that we investigate

$$E\left(i_{1,t}\middle|z_t\right) = \Phi\left(\frac{z_t'\gamma}{\sigma_1}\right)\left(z_t'\alpha + \sigma\lambda\left(\frac{z_t'\gamma}{\sigma_1}\right)\right)$$

- where $\lambda\left(\frac{z_t'\gamma}{\sigma_1}\right) \equiv \frac{\phi\left(\frac{z_t'\gamma}{\sigma_1}\right)}{\Phi\left(\frac{z_t'\gamma}{\sigma_1}\right)}$.