Impact of Foreign Official Purchases of U.S. Treasuries on the Yield Curve

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Abstract

Foreign governments went from owning a tenth of publicly available US Treasury notes and bonds in 1985 to over half in 2008. Recently, foreign governments have reduced their Treasury positions. I find foreign official purchases have depressed medium-term yields, despite conventional wisdom pointing towards the long end of the yield curve. To examine effects over the entire yield curve, I embed a structural vector autoregression of macroeconomic variables into an affine term structure model. With segments of the yield curve increasingly determined by international financial markets, it may be more difficult for the Federal Reserve to implement its interest rate policy.

Keywords: Foreign official purchases, Treasury securities, yields, term structure.

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1 Introduction

Foreign governments went from owning a tenth of publicly available US Treasury notes and bonds in 1985 to over half in 2008. Recently, foreign governments have reduced their Treasuries positions.[1] This paper studies the impact of foreign official purchases on the entire yield curve. Previous literature has focused on the long end of the curve, but the fact that foreign governments mostly own Treasuries maturing in less than four years suggests shorter term rates may respond more.[2]

Distinguishing which part of the yield curve foreign official purchases move is important for monetary policy. If US interest rates are increasingly determined by international financial markets, then it may be more difficult for the Federal Reserve to implement its interest rate policy. For instance, if foreign official purchases mostly influence the middle of the yield curve—as I find to be the case—then these rates may not track the federal funds rate. Additionally, if foreign governments decide to sell off their sizable Treasury positions—as they appear to be doing—the middle of the yield curve could remain stubbornly high and warrant the Fed to direct asset purchases towards these maturities during the next downturn.

This paper embeds a structural vector autoregression (SVAR) of macro variables into a Gaussian affine term structure model (ATSM). The advantage of using a SVAR is that it assumes foreign governments react to economic conditions and only counts the residual as a shock. I then feed these shocks into a macro-finance model of the yield curve to trace out the implied path of yields.

2 Affine Term Structure Models

ATSMs exploit a convenient property of the Treasury market: different maturities of the same asset are traded at the same time. ATSMs assume any difference in Treasury rates

[1] The level of foreign official holdings started to decline in 2016. The ratio, as a share of publicly available Treasuries outstanding, started to decline in 2009. See Appendix A for a figure depicting the latter.

[2] Bernanke, Reinhart and Sack (2004); Warnock and Warnock (2009); Martin (2014); and Barnett, Zmitrowicz et al. (2018) focus on the 10-year yield. Beltran et al. (2013) focus on the 5-year yield.

across maturities is a function of investors' attitude towards risk and not because of an arbitrage opportunity. In other words, the price of an n-period bond at time t is the expected discounted value of an $n-1$ period bond at time $t+1$,

$$P_{n,t} = E_t M_{t+1} P_{n-1,t+1}, \tag{1}$$

where M_{t+1} is the discount factor.

In order to bring this structure to data, ATSMs assume a particular functional form for the discount factor, namely,

$$M_{t+1} = \exp[-r_t - \frac{1}{2}\lambda_t'\lambda_t - \lambda_t' u_{t+1}], \tag{2}$$

where λ_t characterizes investor attitude toward risk. When $\lambda_t = 0$, this corresponds to risk neutrality and the strong form of the expectations hypothesis.[3]

A set of factors, F_t, determine yields.[4] For this application, I assume there are $N_m = 4$ macro factors stacked in column vector f_t^m (one of which is foreign official purchases), and $N_\ell = 3$ latent factors stacked in column vector f_t^ℓ.[5] The macro factors and 11 of their monthly lags, along with the contemporaneous latent factors, make up $F_t = [f_t^{m\prime}, f_{t-1}^{m}{}', ..., f_{t-11}^{m}{}', f_t^{\ell\prime}]'$. These factors are assumed to be an affine function of their lags,

$$F_t = c + \rho F_{t-1} + \Sigma u_t. \tag{3}$$

Gaussian ATSMs make three additional assumptions. First, the residuals in equation (3) are assumed to be Gaussian,

$$u_t \sim \text{i.i.d.} N(0, I). \tag{4}$$

[3]The strong form of the expectations hypothesis is in contrast to what Gürkaynak and Wright (2012) refer to as the weak form, which allows for maturity-specific term premia to be constant over time.

[4]Originally, ATSMs were used to uncover three latent factors which were interpreted as "level," "slope," and "curvature." See, for example, Dai and Singleton (2000), (2002); Duffee (2002); Kim and Orphanides (2005); Kim and Wright (2005).

[5]Ang and Piazzesi (2003) popularized the inclusion of both observable and unobservable factors in ATSMs.

ATSMs further assume that the market price of risk is itself an affine function of F_t,

$$\lambda_t = \lambda_0 + \lambda_1 F_t. \tag{5}$$

Lastly, ATSMs assume that the short rate r_t is an affine function of the factors,

$$r_t = \delta_0 + \delta_1' F_t. \tag{6}$$

Given assumptions (1)-(6), an n-period bond yield (defined as $y_{n,t} \equiv -\frac{1}{n} \ln P_{n,t}$) can be written as an affine function of the factors,

$$y_{n,t} = \alpha_n + \beta_n' F_t, \tag{7}$$

where the constant terms and factor loadings take the following recursive formulations:

$$\begin{aligned}
\alpha_n &= -\frac{1}{n}(-\delta_0 + \alpha_{n-1} + \beta_{n-1}' c - \beta_{n-1}' \Sigma \lambda_0 + \frac{1}{2} \beta_{n-1}' \Sigma \Sigma' \beta_{n-1}) \\
\beta_n &= -\frac{1}{n}(-\delta_1 + \beta_{n-1}' \rho - \beta_{n-1}' \Sigma \lambda_1).
\end{aligned}$$

In other words, if I know the structural parameters $\{c, \rho, \lambda_0, \lambda_1, \delta_0, \delta_1, \Sigma\}$ and the factors F_t, I can calculate the yield of any maturity.[6]

3 Identification

I make three additional sets of identifying assumptions. Before I get there, a quick word on notation: the subscript (or superscript) m indicates coefficients corresponding to the macro factors, and ℓ indicates coefficients corresponding to the latent factors.

Following Ang and Piazzesi (2003), I assume that macro dynamics are independent from the unobserved latent factors. Additionally, I assume a Cholesky identification scheme for

[6]See Ang and Piazzesi's (2003) for a derivation.

the macro variables (i.e. Σ_{mm} is lower triangular) and order foreign official purchases last in f_t^m. This timing restriction assumes foreign governments react to contemporaneous macro variables but not vice versa. Together these first two assumptions allow me to estimate a SVAR in the macro variables to identify how innovations in foreign official purchases impact macro outcomes. I then feed these predictions into the ATSM model—since equation (7) gives a closed-form solutions for how macro factors influence yields—and trace out the implied path of yields.

The next set of assumptions normalizes the latent factors. As discussed in Hamilton and Wu (2012), without restrictions on the latent variables, multiple configurations give observationally-equivalent yields. I choose one set of restrictions so the model is identified but other choices result in the same implied path for yields. Specifically, I assume the slope coefficients on the latent factors in equation (3) are lower triangular with diagonal elements ordered $\rho_{\ell\ell(1,1)} \geq \rho_{\ell\ell(2,2)} \geq \rho_{\ell\ell(3,3)}$. I also assume the three latent factors are orthogonal to each other and that $c_\ell, c_m = 0$. This last assumption does not affect the macro variables since I demean the macro data.

The final set of restrictions ensures there is not an overabundance of structural parameters to recover from the reduced form. Because data is monthly, I include 11 lags of the macro variables; however, to cut down on parameters, I only include one lag of the latent factors. Finally, I set the last element of λ_0 to zero. This means the time-varying risk associated with the third latent factor is not an affine function of the factors but rather a linear combination.

4 Data

Time series data for net foreign official purchases of US Treasury notes and bonds is from Bertaut and Tryon (2007) and Bertaut and Judson (2014).[7] The exact variable I use is net

[7] Data is available for download at:
http://www.federalreserve.gov/pubs/ifdp/2007/910/ticdata.zip
http://www.federalreserve.gov/pubs/ifdp/2014/1113/ifdp1113_data.zip

foreign official purchases, scaled by the value of Treasury notes and bonds held by the public. Data for Treasury securities outstanding minus the amount held in US government accounts and Federal Reserve Banks, and excluding Treasury bills, is from the Center for Research in Security Prices (CRSP) and is a historical 12-month moving average to eliminate seasonality. Appendix A illustrates how scaling net foreign official purchases by Treasuries outstanding gives a stationary series. The series stops in August 2014 because in subsequent years, the Treasury Department (on several occasions) temporarily suspended reinvestment of federal employee retirement funds into new Treasuries to avoid the looming debt ceiling. These occurrences are problematic because they resulted in large fluctuations of publicly available Treasuries outstanding.[8]

Data for the remaining baseline macro factors is from the FRED database of the Federal Reserve Bank of St. Louis. This includes US output growth and inflation which are the 12-month percentage change in industrial production and CPI. This also includes dollar appreciation as measured by a weighted average of the US dollar against currencies from a broad group of major US trading partners.[9]

The $N_\ell = 3$ latent factors are estimated using monthly data on $N = 6$ bond yields. In order to explain three latent factors using six yields, I assume three yields contain measurement error. Specifically, I assume the one-, three-, and six-year yields are priced *without* error, $Y_t^1 = (y_t^{12}, y_t^{36}, y_t^{72})'$, and the two-, four-, and five-year yields are priced *with* error, $Y_t^2 = (y_t^{24}, y_t^{48}, y_t^{60})'$. I use the one-year yield y_t^{12} as a proxy for the observed short rate r_t.[10] Yields are constructed using zero-coupon yields from Gürkaynak, Sack and Wright (2007) and are divided by 1200 in order to convert to monthly fractional rates. The sample period runs from January 1985 through August 2014.

[8]The Federal Reserves's large-scale asset purchases during the Great Recession may also potentially conflate results so Appendix A excludes the Great Recession. Results for this subsample have a similar pattern to baseline, but the effects of foreign official purchases are even larger.

[9]Results are robust to replacing this dollar index with the 12-month percent change in the Japan-US exchange rate.

[10]Term structure models often use the three-month yield to proxy for the observed short rate; however, the three-month and one-year are highly correlated with a correlation coefficient of 0.994 over 1985-2014.

5 Estimation

Since I assume the latent factors are orthogonal to the macro factors, the short rate r_t in equation (6) can be interpreted as arising from a version of the Taylor (1993) rule, where the error $v_t = \delta'_{1\ell} f^\ell_t$ is the unpredictable component of monetary policy. Here, I allow the central bank to react to all macro variables in f^m_t. The Federal Reserve considers hundreds of variables when conducting monetary policy so this approach is simply a more general treatment of the monetary policy rule assumed by Ang and Piazzesi (2003).[11] I directly obtain values of δ_0 and δ_{1m} from OLS estimation.

To recover the rest of the parameters, Hamilton and Wu (2012) show that ATSMs where N_ℓ linear combinations of yields are assumed to be priced without error, can be written as a restricted vector autoregression. Imposing the assumptions outlined in Section 3 results in the following reduced from:

$$
\begin{aligned}
f^m_t &= \phi^*_{mm} F^m_{t-1} + u^*_{mt} \\
Y^1_t &= A^*_1 + \phi^*_{1m} F^m_{t-1} + \phi^*_{11} Y^1_{t-1} + \psi^*_{1m} f^m_t + u^*_{1t} \\
Y^2_t &= A^*_2 + \phi^*_{2m} F^m_t + \phi^*_{21} Y^1_t + u^*_{2t},
\end{aligned}
$$

where F^m_t is a $12 \times N_m$ element vector of contemporaneous and lagged macro variables; F^m_{t-1} is a $12 \times N_m$ element vector of lagged macro variables; Y^1_{t-1} is an N_ℓ element vector of the one-month lags of exactly priced yields; and Y^2_{t-1} is an $N - N_\ell$ element vector of the one-month lags of yields priced with error.

The mapping between the structural parameters (in equation (7)) and the reduced-form parameters (above with stars) can be found in Appendix B. The system satisfies the necessary conditions for identification. In fact, the system is over-identified: it contains more estimated reduced-form parameters than unknown structural parameters. I obtain the

[11] Some of the specifications in Ang and Piazzesi (2003) include lags of inflation and real activity in the Taylor rule. I assume a policy rule that only depends on contemporaneous variables but includes four rather than two macro variables.

reduced-form coefficients from estimating the above equations via OLS. I then use Hamilton and Wu's minimum-chi-square estimation strategy to recover the structural parameters. The system converges and is robust to many initializations.

6 Results

The impact of each factor on an n-length bond is determined by the factor loadings β_n in equation (7). Figure 1 plots these loadings as impulse response functions to a one standard deviation change in the macro variables.[12] Responses of six maturities are plotted.

The upper left panel shows yields increase with output growth. As the US economy grows, investors pullout of safe assets, putting upward pressure on these yields.

The upper right panel shows yields increase with inflation. The correlation is large but not persistent. Since nominal rates are the sum of real rates and inflation, it makes sense that this relationship is particularly strong in the short-run.

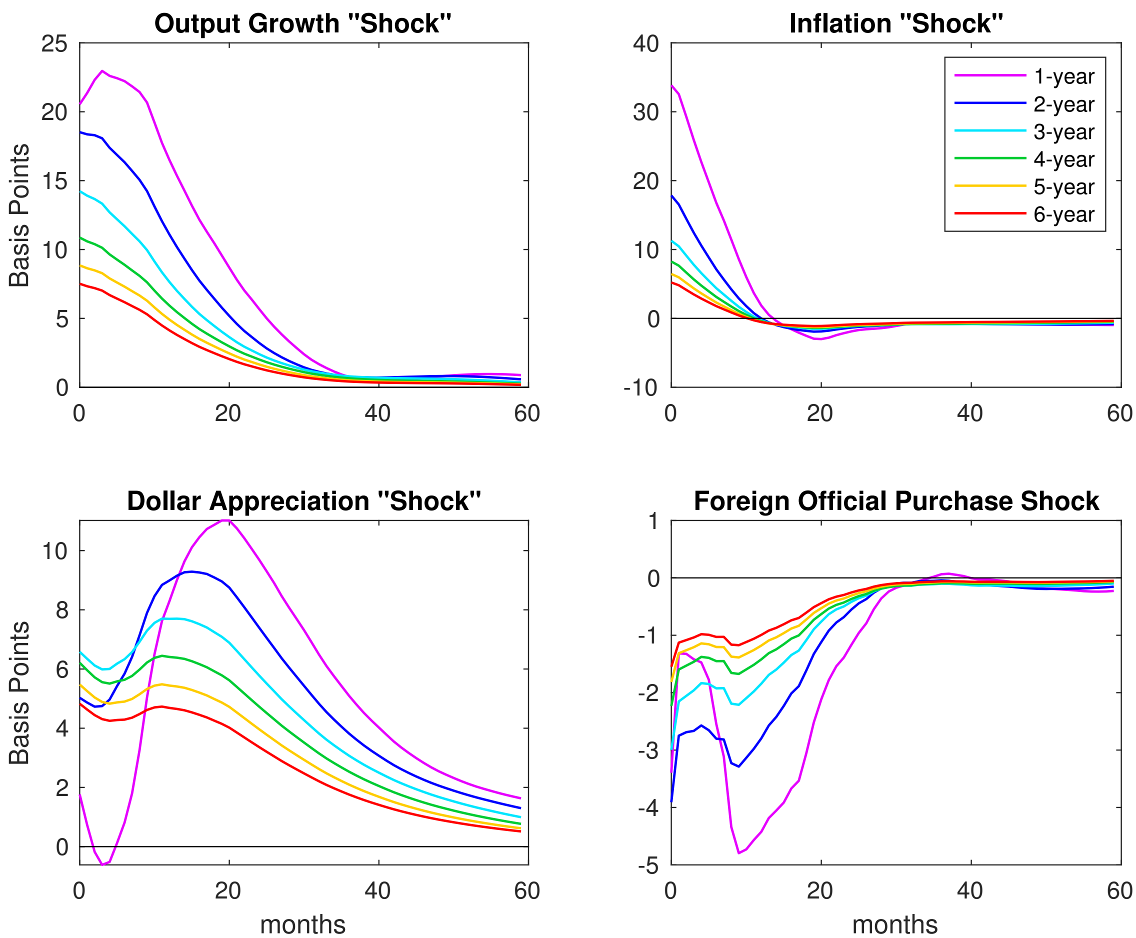
The lower left panel shows yields also increase with dollar appreciation. Investors chase yields, so when US yields rise, there is more demand for US currency, and the dollar appreciates.

The lower right panel is the main figure. A one standard deviation shock to foreign official purchases—after controlling for growth, inflation, and dollar appreciation—initially reduces the two-year yield the most and the six-year yield the least. Since the standard deviation of foreign official purchases is 0.31 of a percentage point, this means an inflow equal to one percent of publicly held Treasury notes and bonds initially lowers the two-year yield by 13 basis points and the 6-year yield by about 5 basis points.[13] The one-year yield is sensitive to the specification which could explain its bizarre shape. Nevertheless the two- and three-year yields robustly fall more than any of the other yields, regardless of the

[12] See Appendix A for impulse response functions of the macro variables in response to macro shocks, before the implied effects are traced out for yields.

[13] Using their VAR approach, Beltran et al. (2013) find an inflow equal to one percent of the amount of Treasuries outstanding lowers the five-year yield by 5-6 basis points. I find the five-year yield falls by 5.9 basis points.

Figure 1: Response of Yields to One Standard Deviation Shock of Macro Variables



specification. Two years after the shock, effects on all yields tapper off.

According to TIC, since the early 2000s, a large share of foreign-held Treasuries mature in just a few years.[14] For example, in 2014, 38 percent of Treasuries held by foreign governments were scheduled to mature in one to three years, and the majority were scheduled to mature in under four years. In other words, the type of assets foreign governments own are the ones most affected by their purchases.

7 Conclusion

This paper asks whether the massive acquisition (and recent offloading) of US Treasuries by foreign governments has altered the yield curve. I find that, yes, the increase in demand shifted the entire yield curve down, with the largest effects on the one- to three-year yields. This suggests that leading up to the Great Recession, the middle of the yield curve was lower than it would have been in the absence of foreign official purchases. On the flip side, in 2016, foreign governments offloaded 2 percentage points of Treasuries outstanding, likely putting upward pressure on the middle of the curve.

[14]See Appendix A for the maturity structure of foreign official portfolio holdings available from TIC since 2004.

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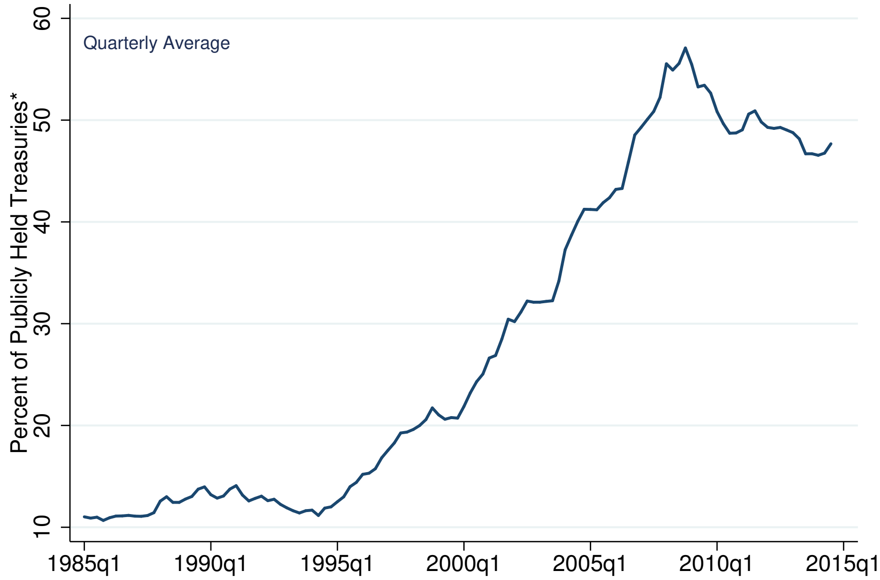
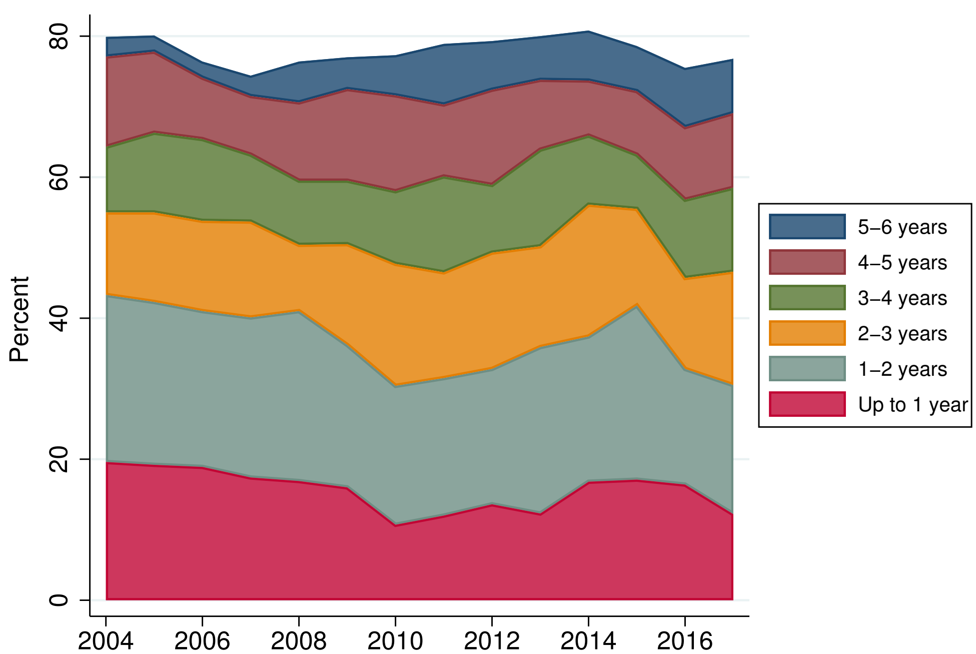
A Appendix

Figure 2: Foreign Official Holdings of US Treasury Notes and Bonds



*Excludes Treasury Bills. Sources: Bertaut and Tyron (2007), Bertaut and Judson (2014), CRSP.

Figure 3: Maturity Structure of Foreign Official Holdings of US Treasuries



Source: Treasury International Capital (TIC). Data reported as of June 30 that year.

Figure 4: Scaling Net Foreign Official Purchases by Treasuries Outstanding

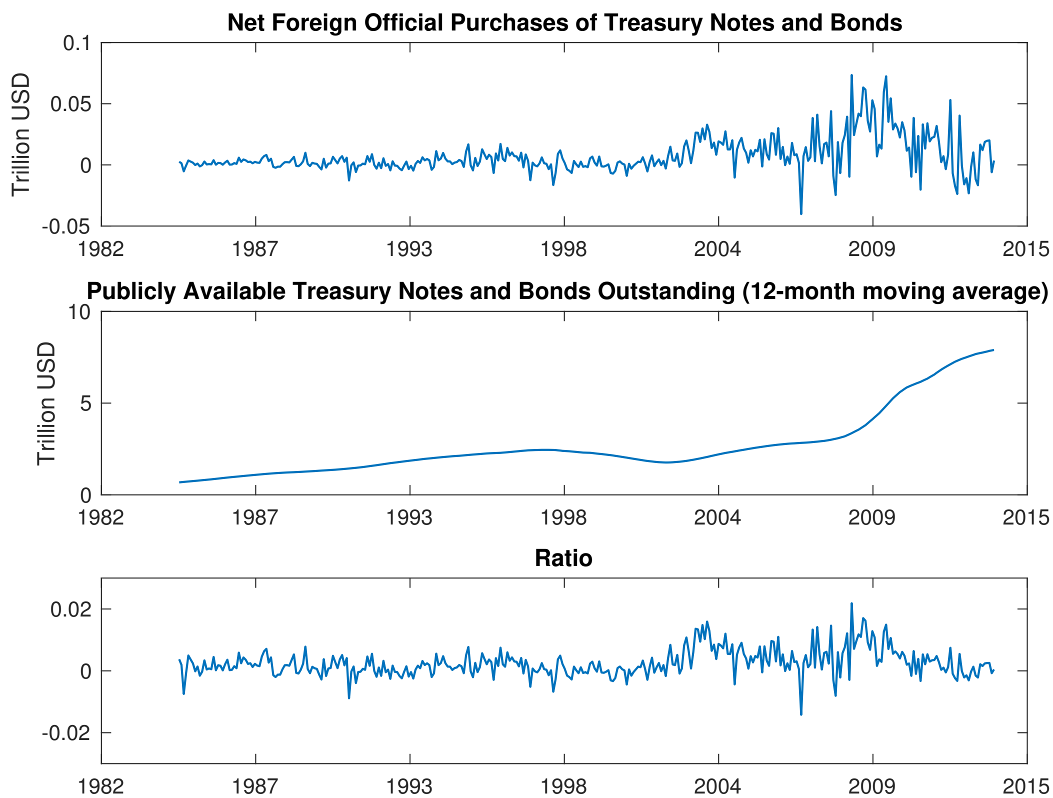
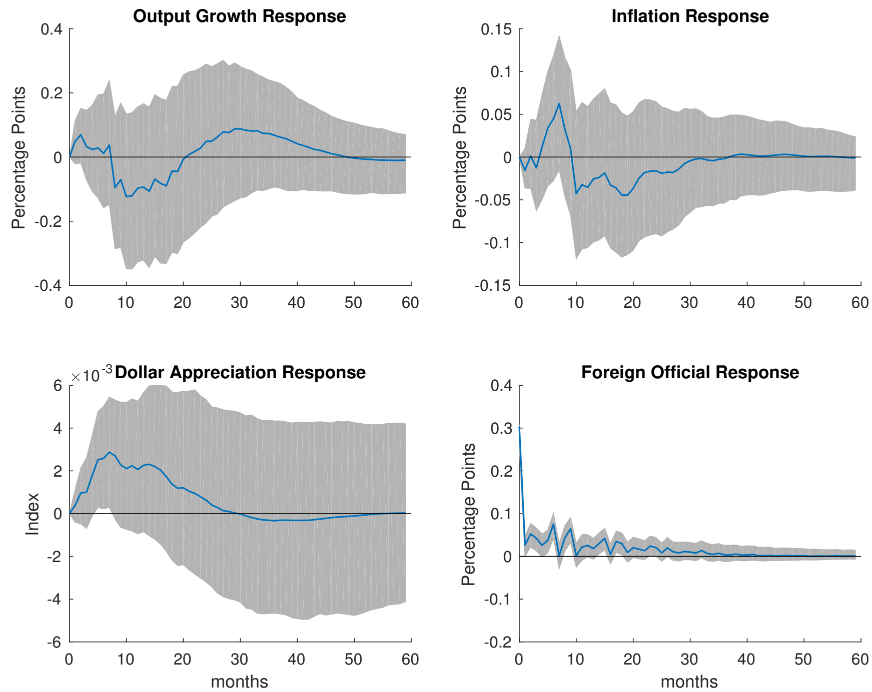
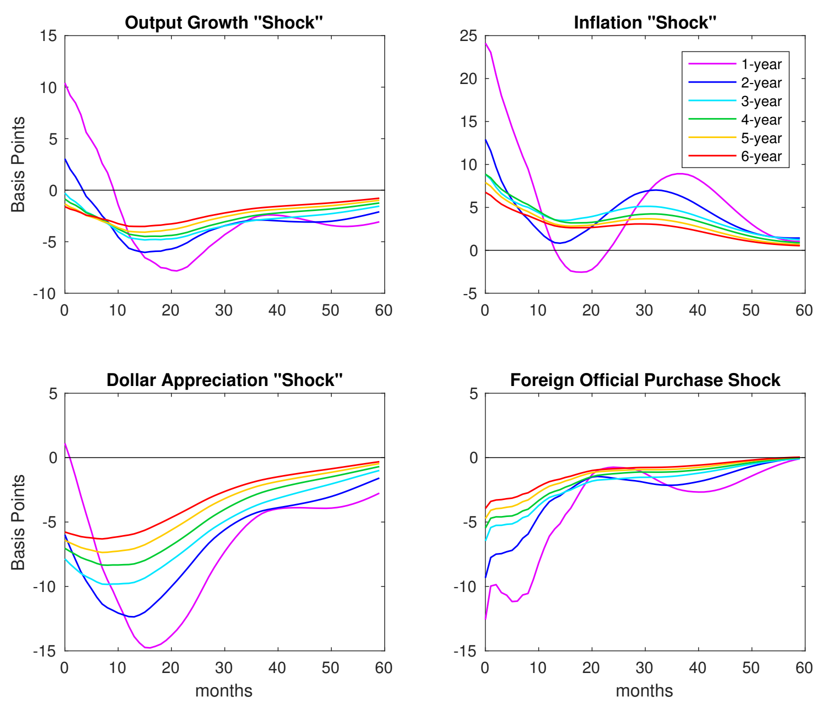


Figure 5: Response of Macro Variable SVAR to Foreign Official Purchase Shock



90 percent bootstrapped confidence intervals

Figure 6: Response of Yields Excluding the Great Recession*



*Sample period 1985m1-2007m11

B Appendix: Parameter Mapping

The mapping between structural and reduced-form parameters follows:

$$\phi^*_{mm} = [\rho_1\ \rho_2\ ...\ \rho_{12}]$$

$$A^*_1 = A_1 - B_{1\ell}\rho_{\ell\ell}B^{-1}_{1\ell}A_1$$

$$\phi^*_{1m} = \begin{bmatrix} B^{(1)}_{1m} & 0 \end{bmatrix} - B_{1\ell}\rho_{\ell\ell}B^{-1}_{1\ell}\begin{bmatrix} B^{(0)}_{1m} & B^{(1)}_{1m} \end{bmatrix}$$

$$\phi^*_{11} = B_{1\ell}\rho_{\ell\ell}B^{-1}_{1\ell}$$

$$\psi^*_{1m} = B^{(0)}_{1m}$$

$$A^*_2 = A_2 - B_{2\ell}B^{-1}_{1\ell}A_1$$

$$\phi^*_{2m} = B_{2m} - B_{2\ell}B^{-1}_{1\ell}B_{1m}$$

$$\phi^*_{21} = B_{2\ell}B^{-1}_{1\ell}$$

$$\text{Var}\begin{bmatrix} u^*_{mt} \\ u^*_{1t} \\ u^*_{2t} \end{bmatrix} = \begin{bmatrix} \Omega^*_m & 0 & 0 \\ 0 & \Omega^*_1 & 0 \\ 0 & 0 & \Omega^*_2 \end{bmatrix} = \begin{bmatrix} \Sigma_{mm}\Sigma'_{mm} & 0 & 0 \\ 0 & B_{1\ell}B'_{1\ell} & 0 \\ 0 & 0 & \Sigma_e\Sigma'_e \end{bmatrix},$$

where $\hat{\Sigma}_{mm}$ is the Cholesky factorization of $\hat{\Omega^*_m}$ and $\hat{\Sigma}_e$ is the square root of the diagonal elements of $\hat{\Omega^*_2}$.[15] Additionally, A_1, A_2, B_1, B_2 are defined as:

$$\begin{bmatrix} A_1 \\ A_2 \end{bmatrix} = \begin{bmatrix} \alpha_{12} \\ \alpha_{36} \\ \alpha_{72} \\ \alpha_{24} \\ \alpha_{48} \\ \alpha_{60} \end{bmatrix},$$

[15] Macro variables in f^m_t are ordered as follows: output growth, inflation, exchange rate, foreign official purchases scaled by publicly-held Treasury notes and bonds outstanding.

$$\begin{bmatrix} B_{1m}^{(0)} & B_{1m}^{(1)} & B_{1\ell} \\ B_{2m}^{(0)} & B_{2m}^{(1)} & B_{2\ell} \end{bmatrix} = \begin{bmatrix} \beta'_{12} \\ \beta'_{36} \\ \beta'_{72} \\ \beta'_{24} \\ \beta'_{48} \\ \beta'_{60} \end{bmatrix},$$

where for $i = 1, 2$, $B_{im}^{(0)}$ are (3×4) matrices relating the observed yields to the 4 contemporaneous macro factors. $B_{im}^{(1)}$ are (3×44) matrices relating the observed yields to 11 lags of the 4 macro factors. Lastly, $B_{i\ell}$ are (3×3) matrices relating the observed yields to the latent factors.