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Daniel O. Beltran

Maxwell Kretchmer

Jaime Marquez

Charles P. Thomas

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Daniel O. Beltran, Maxwell Kretchmer, Jaime Marquez, Charles P. Thomas*

Abstract

Foreign official holdings of U.S. Treasuries increased from $400 billion in January 1994 to about $3 trillion in June 2010. Most of this growth is accounted for by a handful of emerging market economies that have been running large current account surpluses. These countries are channeling their savings through the official sector, which is then acquiring foreign exchange reserves. Any shift in policy to reduce their current account surpluses or dampen the rate of reserves accumulation would likely slow the pace of foreign official purchases of U.S. Treasuries. Would such a slowing of foreign official purchases of Treasury notes and bonds affect long-term Treasury yields? Most likely yes, and the effects appear to be large. By our estimates, if foreign official inflows into U.S. Treasuries were to decrease in a given month by $100 billion, 5-year Treasury rates would rise by about 40-60 basis points in the short run. But once we allow foreign private investors to react to the yield change induced by the shock to foreign official inflows, the long-run effect is about 20 basis points.

Key words: Foreign official inflows, Treasury yields, reserves, capital flows

JEL codes: F31, F32, F34

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1 Introduction

As economies are becoming increasingly financially integrated, longer-term bond yields are increasingly determined in international markets. This calls into question the ability of central banks to influence longer-term interest rates by the setting of short-term rates. For example, Greenspan (2005) was concerned about the failure of the longer-term interest rates to rise after the Fed began tightening monetary policy starting in mid-2004 (figure 1). During this period, foreign purchases of Treasury notes and bonds were particularly strong (figure 2), and some studies (Warnock and Warnock (2009) and Bernanke, Reinhart, and Sack (2004)) found evidence that these purchases contributed to lower bond yields. Such a decoupling of long-term interest rates from the short-term interest rate, which is set by the monetary authority, has important implications for the effectiveness of monetary policy. In addition, unexpected shifts in foreign demand for U.S. Treasuries could cloud the signals extracted from movements in long-term interest rates.

Bernanke (2005) has attributed some of the decline in long-term interest rates in the United States and other advanced economies since 2000 to a "global savings glut." Indeed, global foreign exchange reserves have risen sharply since 2000 (figure 3). A significant share of global foreign exchange reserves are invested in U.S. Treasury securities– the share was 36 percent as of June 2010. As shown by the red area in figure 4, foreign official holdings of U.S. Treasuries increased from \$400 billion in January 1994 to about \$3 trillion in June 2010. Most of this growth is accounted for by a handful of emerging market economies that have been running large current account surpluses. Figure 5 plots the geography of total foreign holdings of U.S. Treasury securities over time. As shown by the combined pink areas, China, Japan, and the other emerging market countries experienced the fastest growth. These countries are channeling their savings through the official sector, which is then acquiring foreign exchange reserves. Any shift in policy to reduce their current account surpluses or dampen the rate of reserves accumulation would likely slow the pace of foreign official purchases of U.S. Treasuries.

Would such a slowing of foreign official purchases of Treasury securities affect their yields? As acknowledged by Wu (2005), answering this question is difficult for many reasons, most of which have not been adequately addressed in the literature. First, the direction of causation between foreign demand for Treasury securities and their prices (or yields) is likely to go both ways. Second, long-term interest rates are influenced by forward looking variables which are typically unobservable, such as expectations of long-run inflation and other macroeconomic variables, which makes identifying the effects of foreign official inflows more difficult. Third, changes in asset prices induced by shifts in foreign official demand may be, in time, partially offset by the actions of private investors. So not taking these actions into account may bias the estimated effect of foreign official purchases. Finally, data on interest rates, macroeconomic variables, and foreign holdings are often highly autocorrelated or even non-stationary, so the potential for "discovering" spurious relationships is great when fitting the levels of the economic time series (Granger and Newbold (1974)). The goal of this paper is to uncover the relationship between foreign purchases of U.S. Treasury securities and their yields while avoiding these traps. This task requires a more sophisticated modeling approach than the single-equation methodology popular in the literature.

The first of these traps is neglecting the interdependency between Treasury prices and foreign demand. Nearly all previous studies assume that foreign governments do not optimize their foreign reserves portfolio, thus treating foreign official inflows as exogenous.[1] However, surveys of central banks suggest that most reserve managers in fact do change their reserve portfolios in response to changes in Treasury prices and other macroeconomic variables. For example, a recent survey by the BIS found that reserve managers are increasingly behaving like private asset managers, emphasizing returns relative to liquidity and capital preservation (Borio, Galati, and Heath (2008)).[2] The BIS survey indicated that over two-thirds of central banks employ external managers, that almost all central banks use value-at-risk methodologies to measure market risk. Papaioannou, Portes, and Siourounis (2006) and others have found evidence suggesting that central banks pursue a mean-variance portfolio diversification strategy. Indeed, as shown below, our statistical tests strongly reject the null hypothesis that foreign official inflows into U.S. Treasuries are exogenous to changes in Treasury prices. Foreign private flows are also likely to be endogenous, but we did not find strong and valid instruments for them.

To address the second concern– that long-term interest rates are influenced by forward looking expectations which are typically unobservable– we use two measures of risk premia: the term-premium derived from the three-factor affine term-structure model of D'Amico, Kim, and Wei (2010), and realized excess holding period returns. By construction, both of these measures of risk premia are undistorted by the effects of expected changes in the Fed's monetary policy stance.

To avoid the potential for discovering spurious relationships from regressions on highly correlated or non-stationary data, we difference the data to obtain flow measures for our variables. By using data expressed in first differences, we are estimating the short run elasticity between foreign official flows and changes in yields. Previous studies use cumulated 12-month flows (Warnock and Warnock (2009)) and the level of foreign holdings (Bertaut, DeMarco, Kamin, and Tryon (2011)) to estimate the long-run effect on yields. However, the variables

[1]One exception is Sierra (2010).

[2]An older survey by Pringle and Carver (2002) also suggests increased emphasis on returns or yield.

used in these studies are either highly autocorrelated, non-stationary, or trend-stationary.[3] Thus, when estimating the long-run effect, we use a cointegrated vector auto-regression (VAR) model which is suitable for regressing non-stationary variables.

Controlling for the actions of foreign private investors to any misalignments in Treasury yields induced by changes in foreign official demand requires a more sophisticated model. Foreign private investors may trade both short- and long-term securities for hedging or speculative purposes, and may also view U.S. sovereign bonds and say, German sovereign bonds as close substitutes. Our VAR model captures the interactions between foreign official and foreign private flows into long-term Treasuries.

The remainder of this paper is organized as follows. In the next section we describe the data used to estimate our models. In section 3 we examine the effects of foreign inflows into U.S. Treasuries on the term premium, using OLS, two-stage least squares, and cointegrated VAR models. The following section conducts a similar analysis on realized excess returns. In section 5 we place our results in the context of the existing literature. The last section concludes.

2 Data

2.1 Interest rates and risk premia

Following Dai and Singleton (2002), we define the term premium for an $n-$period bond as

$$TP_t^n \equiv R_t^n - \underbrace{\frac{1}{n}\sum_{i=0}^{n-1} E_t(r_{t+i})}_{\text{EH component}} \tag{1}$$

where R_t^n is the yield of an n-period zero-coupon bond at time t, and $r_t \equiv R_t^1$ is the short rate. Equation 1 can be used to decompose the long-term rate into the "expectations hypothesis" (EH) component, which measures the expected path of the short rate, and the term-premium component, which measures inflation risk, liquidity risk, and other risk factors that affect the long-rate. Thus, in principle, the term premium is undistorted by the expected changes in Fed's monetary policy stance.

We focus on the 5-year term-premium for U.S. Treasury securities because this maturity is close to the average maturity of U.S. Treasury and agency securities held by foreigners,

[3]We arrived at this conclusion by examining the augmented Dickey-Fuller statistic and autocorrelation function of the variables used in their regressions.

and because prices of 5-year Treasury notes are readily observed.[4] The expected path of the short rate in equation 1 is not observable, which makes the term premium unobservable as well. Both are derived from the arbitrage-free 3-factor term-structure model of D'Amico, Kim, and Wei (2010) which builds upon the model of Kim and Wright (2005). The model uses a continuous-time nominal stochastic discount factor to derive the price of an n-period nominal zero-coupon bond. Arbitrage-free pricing implies that once risk is factored into account, there are no arbitrage opportunities from buying one security and shorting some combination of other securities. Three underlying latent factors are used to describe the behavior of the yield curve through time. Although these factors have no macroeconomic interpretation, they are often related to the level, slope, and curvature of the yield curve.[5]

The term-premium described above is a model-dependent and *ex-ante* measure of risk premium. But we also consider an *ex-post* measure of risk premia that is not model dependent: realized excess returns. More specifically, we use the holding period return from buying a 6-year bond at time t and selling it as a 5-year bond 1 year later, minus the return of a 1-year bond:

$$D_{t+1}^{6} = \ln \frac{P_{t+1}^{5}}{P_{t}^{6}} - r_t. \tag{2}$$

We compute D_{t+1}^{6} using the fitted zero-coupon yield curve estimates of Gurkaynak, Sack, and Wright (2007).

Figure 6 illustrates the timing of bond-purchases that give rise to the excess returns realized one-year ahead. At time t, the investor borrows funds for 1-year at a fixed rate r_t to purchase a 6-year Treasury bond. The investor holds the bond for 1 year (the holding period), during which its price will fluctuate because of changing macroeconomic fundamentals and possibly (as we will test) changes in foreign demand for Treasury securities. Excess returns are realized at time $t+1$ when the 6-year bond is sold as a 5-year bond, and the 1-year loan is paid off.

Our two measures of risk premium are conceptually related to each other– the term premium is equal to the average of future realized excess returns for bonds of decreasing maturity.[6] Figure 7 compares our ex-ante measure of risk premium (the 5-year term-premium) to our ex-post measure of risk premium (excess holding period return of a 6-year bond realized 1-year in the future). Although realized excess returns are more volatile then the term premium, the

[4]Roughly half of the Treasury and agency securities held by foreign official investors mature in 5 years or less (Department of the Treasury (2011)).

[5]The D'Amico, Kim, and Wei (2010) model is estimated by applying the Kalman filter to the following data: zero coupon yields taken from the Svensson curve (Svensson (1994)) that is fitted to off-the-run Treasury coupon securities, 3-month and 6-month Treasury bill yields, CPI inflation, TIPS yields, the 6-month and 12-month ahead forecasts of the 3-month T-bill yield from Blue Chip Financial Forecasts, and the Blue Chip forecast of the 3-month T-bill yield over the next 5 to 10 years.

[6]It can be shown that for an n-year bond, $TP_t^n = \frac{1}{n}\sum_{i=1}^{n-1} E_t(D_{t+i}^{n-i+1})$.

two measures are positively correlated (the Pearson's product-moment correlation is 0.45 with a t-statistic of 6.36).

Because foreign official flows occur during the holding period, they can only influence the price of the 5-year bond (originally purchased as a 6-year bond) when it is sold at the end of the holding period, P^5_{t+1}. Thus our a-priori hypothesis is that unanticipated foreign bond purchases occurring during the holding period would exert upward pressure on P^5_{t+1}, thus increasing excess returns realized at time $t+1$.

2.2 Foreign holdings of Treasury securities

We use monthly data from the Treasury International Capital (TIC) reporting system, which is the most complete source for data on foreign official and foreign private net purchases of U.S. Treasury notes and bonds, (gross purchases by foreign residents minus gross sales by foreign residents).[7]

A well known problem with the monthly TIC transactions data is that they undercount foreign official acquisitions of U.S. securities because they do not capture acquisitions through foreign intermediaries (Bertaut, Griever, and Tryon (2006)).[8] To estimate the "missing flows," we make use of the detailed and more accurate annual reports on foreign holdings of U.S. securities (as in Bertaut and Tryon (2007) and Warnock and Warnock (2009)), as well as data on custodial holdings at FRBNY.[9] Further, the adjusted flows are "survey consistent" because they insure that the change in measured holdings between two annual surveys equals the sum of cumulated flows during the period and the estimated valuation change; this approach for estimating flows improves upon the approach of Warnock and Warnock (2009) and Bertaut and Tryon (2007) because we perform an additional adjustment based on changes in custody holdings at FRBNY.[10]

As noted earlier, foreign official investors have been acquiring Treasuries at a much faster pace than foreign private investors. The share of all Treasuries held by official investors has climbed from 15 percent in 1994 to 46 percent in 2007 (figure 8). Foreign investors have also

[7] The data come from the annual and monthly survey forms, and can be found on the Treasury Department's website at www.treasury.gov/tic.

[8] For example, an acquisition of a U.S. security by a foreign official institution from a private foreign entity on a foreign securities exchange will not be recorded in the TIC because it is not a U.S. cross-border transaction. Note, however, that the initial acquisition of the U.S. security by the foreign private investor should have been recorded in the TIC.

[9] We use confidential data on amounts held in custody accounts for individual countries at FRBNY to perform these adjustments.

[10] Rudebusch et al. use publicly available data on aggregate custody holdings at the Federal Reserve Bank of New York's (FRBNY) obtained from the H.4.1 statistical release. However, changes in these holdings account for just a fraction (about 60 percent) of overall foreign official flows.

shown an increasing preference for longer-maturity Treasuries. As shown by the black line in figure 9, the share of long-term Treasuries (notes and bonds) held by foreigners has steadily climbed from 30 percent in 1994 to 75 percent in 2007. Meanwhile, the share of short-term Treasuries (bills) held by foreigners, the dashed green line, remained in the 30 to 40 percent range. In this paper we focus our attention on the effects of foreign purchases of long-term Treasuries. Figure 10 shows that the share of long-term Treasuries held by foreign officials steadily increased from 10 to 50 percent between 1994 and 2007, while the private share trailed the official share until 1998 and then flattened out at around 20 percent.

Our sample comprises monthly data from January 1994 to June 2007. The beginning date is restricted by the availability of data for our explanatory variables (discussed later), and the end period is chosen to intentionally exclude the financial crisis period. During the 2007-2011 period, financial markets (and Treasury yields) were very volatile. During this turbulent period, events such as the Lehman bankruptcy and subsequent implosion of repo markets, the near-collapse of AIG and the government agencies Freddie and Fannie, the implementation of the Troubled Asset Relief Program, the commencement of large scale asset purchases by the Fed, and the various episodes of the European sovereign debt crisis would likely obscure the relationships we care about.

2.3 Other control variables

To control for other factors which might affect the term premium, our regressions include the following explanatory variables: (1) Implied volatility of options on U.S. and German five-year sovereign note futures; (2) Liquidity premium (LP) measured as the difference between the synthetic off-the-run and on-the-run five-year Treasury note yields; (3) VIX index of stock market volatility which is correlated with flight-to-safety flows and dollar appreciations; (4) Year-over-year change in industrial production (ΔIP); (5) VAR estimates of exogenous oil-specific demand shocks using the data from Kilian (2009); (6) U.S. federal government budget balance; (7) Cochrane and Piazessi factors (CP_t^{1-5} and CP_t^{6-9}), linear combinations of forward rates that have been shown to forecast future realized excess returns quite well (Cochrane and Piazzesi (2005)), and (8) a measure of global risk appetite developed by Credit Suisse which captures the relative performance of safe assets like government bonds versus volatile assets like equities and emerging country bonds.[11]

[11] Sixty-four global assets are used in Credit Suisse's global risk appetite calculation.

3 Foreign inflows into Treasuries and the term premium

Our a-priori hypothesis is that increases in foreign official and private holdings of U.S. Treasuries exert upward pressure on bond prices, thus lowering yields and the term premium (assuming the expected path of the short-rate remains unchanged). To examine the short-run dynamics between foreign inflows into long-term Treasuries and the 5-year term premium we estimate a model using monthly flow data. We then examine the long-run relationships between foreign inflows and the term premium by estimating a cointegrated VAR model.

3.1 Instrumental variables approach

The instrumental variables model is specified as

$$TP_t^{60} - TP_{t-1}^{60} = \Delta TP_t^{60} = \alpha + \gamma t + \mathbf{X}_t\beta_1 + \mathbf{Z}_t\beta_2 + u_t,\ u_t \sim N(0, \sigma^2) \tag{3}$$

where $\mathbf{X}_t$ is the vector of regressors assumed to be exogenous and $\mathbf{Z}_t$ is the vector of regressors assumed to be endogenous. The explanatory exogenous variables are those described in section 2.3, expressed as changes. The endogenous regressor is the monthly foreign official flow into U.S. Treasury notes and bonds as a share of marketable Treasury notes and bonds outstanding. Because we did not find strong and valid instruments for foreign private flows, we treat this variable as exogenous. When we tried estimating the model treating both private and official flows as endogenous, the estimated coefficient on foreign official flows was practically unchanged, but using weak instruments made the estimated coefficient on foreign private flows extremely sensitive to slight changes in the specification.

We experiment with several instrumental variables that are related to foreign exchange reserve accumulation (which are heavily invested in U.S. Treasuries) but not directly related to risk premia. The instruments are listed below:

- Foreign exchange interventions by Japan's Ministry of Finance ($JPYFXINT_t$) because a sizable portion of the proceeds from these interventions were invested in U.S. Treasuries;[12] We interpret these interventions as an exogenous shock to foreign official inflows into U.S. Treasuries. However, as recognized by Bernanke, Reinhart, and Sack (2004), the potential for joint endogeneity can occur if, for example, weak economic data simultaneously lowers Treasury yields and depreciates the dollar, prompting the Japanese finance ministry to intervene to prevent the yen's appreciation.

[12] These interventions totalled $547 billion between April 1993 and March 2004, and were particularly strong in 2003 as the Ministry of Finance attempted to slow the yen's appreciation.

- Exogenous oil-specific supply shocks from a VAR, obtained from Kilian (2009).
- Sum of Chinese trade and direct investment inflows (BOP_CN_t). We expect that strong trade surpluses or direct investment inflows into China would place pressure on the People's Bank of China to intervene to prevent the renmimbi from appreciating. In turn, these interventions would likely be correlated with larger Chinese foreign official flows into the United States.

The strength of these instruments will be accessed by examining the Cragg-Donald Wald F-statistic. When two or more instruments are used, we judge their validity by the Hansen J-statistic (under the null that the instruments are uncorrelated with the error terms).

Table 1 shows OLS and two-stage least squares (2SLS) estimates; the latter approach treats foreign flows as endogenous. Counter to what we would expect, the coefficient on foreign official and foreign private flows are positive in the OLS specification (column 1), but small. In columns 2 and 3, we use two-stage least squares (2SLS) and scale foreign flows by marketable Treasury securities outstanding. Column 2 shows the first stage results for the regression on foreign official inflows. Japanese interventions and the exogenous oil supply shocks are both associated with stronger official inflows. Increases in the VIX index have a negative effect on foreign official inflows, perhaps because the VIX is an indicator of flight-to-safety behavior by private investors. When the VIX is high, investors are nervous and flee to the relative safety of U.S. Treasuries– the dollar appreciates and the pressure for emerging market countries to intervene to combat the appreciation of their currencies is reduced. Column 3 shows the second stage results, the coefficient on foreign official flows suggests that an inflow equal to one percent of the amount of Treasuries outstanding lowers the 5-year term premium by 13.5 basis points. In June 2007, the amount of marketable long-term Treasuries outstanding held by the public (excluding holdings of the Federal Reserve System) was $2,915 billion. Therefore, our coefficient implies that an inflow of $100 billion into U.S. Treasury notes and bonds would lower the 5-year term premium (and hence the 5-year yield) by 46 basis points (100/29.15*(-13.5)).

In columns 4 and 5, we do the same 2SLS estimation but instead of scaling foreign flows by the amount of Treasuries outstanding, we scale them by U.S. nominal GDP. Because GDP is larger than the amount of Treasuries outstanding, the coefficient becomes larger. U.S. GDP was roughly $14 trillion in June 2007, so the coefficient of -0.696 implies that an inflow of $100 billion into Treasury notes and bonds would lower the 5-year term premium by -50 basis points (100/140*(-69.6)).

The Cragg-Donald Wald F-statistic in specification 3 of 15.7 is a bit below the critical value 19.9 of the Stock and Yogo (2005) size test with size $r = 0.10$, so our instruments are not that strong. However, in specification 5 we may have a weak instruments problem because the Cragg-Donald Wald F-statistic of 9.9 does not pass the 10 percent size test (it does pass the 20% size test). For both IV specifications, the instruments appear to be valid according to the Hansen J statistic; we fail to reject the null that the instruments are uncorrelated with the error terms. For both IV regressions, the Hausmann-Wu endogeneity test rejects the null hypothesis that foreign official flows are exogenous at the 5 percent level of significance. And in both cases, the Pagan-Hall tests fail to reject the null that the residuals are homoscedastic. However, we find some evidence that the residuals may be autocorrelated, as the Cumby-Huizinga tests reject the null that the errors are non-autocorrelated at the 5 percent level. This is somewhat surprising because the variables are already expressed in first differences. Even so, to address the potential problem of autocorrelated residuals, we report Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors.

In columns 1 and 2 of table 2, we try different combinations of included instruments. In specification 1, the instruments appear to be fairly strong and uncorrelated with the error terms, whereas they are weaker in specification 2. But in both cases the second stage coefficients on foreign official flows are similar in magnitude to the one reported in column 3 of table 1. In the third specification, we use foreign official inflows from Japan and instrument them with Japanese foreign exchange interventions.[13] The Cragg-Donald Wald F-statistic of 98 indicates that the instrument is strong, and the coefficient on Japanese official inflows is similar to those found in specifications 1 and 2. In specifications 4 and 5 we examine the effects of official purchases from China and the Mid-East oil exporters, but the instruments are clearly weak in both cases, making these estimates unreliable.[14]

Referring back to figure 2, the widening gap between the blue and red lines between 2004 and 2007 indicate that foreign official investors began diversifying their portfolio of U.S. securities by acquiring increasing amounts of agency securities. To the extent that Treasury and agency securities are close substitutes (at least during our sample period) and foreigners purchased large quantities of both, we consider a broader measure comprising both types of foreign inflows. Using this broader measure of foreign official inflows (scaled by GDP), we run several instrumental variable regressions and present the results in table 3. The instruments appear to be weak as none of the specifications pass the Stock and Yogo (2005) weak instruments test using a 10 percent size. The estimated coefficients from these regressions imply that a $100 billion foreign official inflow into Treasuries and agencies would lower the 5-year term premium by 43 to 70 basis points.

Summarizing the results from the term-premium regressions using instrumental variables,

[13]The regressions in specifications 3-5, done as a robustness check, use confidential data on foreign official inflows from individual countries, which are not publicly available.

[14]The weak results for the China regression could be because, as shown in figure 5, total Chinese holdings of U.S. Treasuries began increasing rapidly only toward the end of our sample period, which ends in 2007.

when the instruments are strong, valid, and the residuals pass the usual tests, the point estimates of the effect of a \$100 billion foreign official inflow into U.S. Treasury notes and bonds on the 5-year term-premium range from -46 basis points to -50 basis points. Furthermore, conditional on having valid and strong instruments, the Hausman and Wu endogeneity tests strongly reject the null hypothesis that foreign official inflows are exogenous, justifying the need to use two-stage least squares.

3.2 Cointegrated VAR Approach

We now apply Johansen's cointegration method to both recognize the endogeneity of the term premium and foreign holdings of U.S. Treasury securities and to characterize the long-run and short-run dynamics between changes in the term premium and foreign holdings of U.S. Treasury securities. The system of equations is as follows:

$$\Delta \mathbf{X}_t = \underbrace{\sum_{k=1}^{n} \underset{3\times 3}{\Gamma_k} \cdot \Delta \mathbf{X}_{t-k} + \underset{3\times 5}{\Psi} \cdot \begin{pmatrix} 1 \\ y_t \\ vol.us_t \\ vol.ger_t \\ vix_t \end{pmatrix}}_{short-run} + \underbrace{\underset{3\times 3}{\Pi} \cdot \mathbf{X}_{t-1}}_{long-run} + \underset{3\times 1}{\mathbf{v}_t}, \quad \text{where} \tag{4}$$

$$\mathbf{v}_t \sim IN(0, \underset{3\times 3}{\Omega}), \text{ and } \Delta \mathbf{X}_t \equiv \begin{pmatrix} \Delta TP_t \\ \Delta FOI_t \\ \Delta FPVT_t \end{pmatrix}.$$

In equation 4, n is the number of lags, Ψ and Γ_k are matrices of parameters characterizing short-run responses, and Π is a matrix of parameters of long-run responses. Foreign official (FOI_t) and foreign private ($FPVT_t$) are scaled by the amount of marketable Treasury notes and bonds outstanding (excluding holdings of the Federal Reserve system).

Central to the Johansen method is the estimation of the *number* of long-run relations, which is given by the rank of Π. To this end, one needs to specify n and we consider several values: 1, 2 4, 6, 8, 10, and 12. For each value of n, we apply FIML to equation (4), and test whether the distribution of $\mathbf{v}_t$ is consistent with the maintained hypotheses. If there is support for these hypotheses, we then test the rank of Π using the Trace and Max tests, both with and without correction for degrees of freedom.

Table 4 shows the results along with statistical criteria (AIC, SC, and HQ) for choosing n. For $n < 2$, the residuals appear to be either autocorrelated, heteroscedastic, or not normally distributed. The SC and HQ criteria would select the models with 1 and 2 lags, respectively, which do not have well-behaved residuals. The AIC criteria favors the model with 4 lags, whose residuals are more like white noise. For $n > 2$, the rank of Π is at most one regardless of the test used, suggesting that the there is only one long-run relation. Given this result, Π can be expressed as $\Pi = \alpha \cdot \beta$, where $\alpha' = \begin{pmatrix} \alpha_1 & \alpha_2 & \alpha_3 \end{pmatrix}$ and $\beta = \begin{pmatrix} \beta_1 & \beta_2 & \beta_3 \end{pmatrix}$; the $\alpha' s$ represent the speed of adjustment to departures from the long-run relation and the $\beta' s$ represent the importance of each factor in determining the long-run. We identify the long-run relation by normalizing $\beta_1 = 1$.

The long-run coefficients under this normalization are presented in table 5. The parameter estimates are fairly insensitive to the lag choice. The β coefficients on foreign official holdings in the term-premium equation range from 0.046 to 0.062, and they are all statistically significant. The coefficients on foreign private holdings are similar in magnitude, but only statistically significant for the specifications with 8 or more lags. The long run relation is given by

$$\widehat{TP}_t^{60} = -0.046 \cdot FOI_t - 0.061 \cdot FPVT_t. \tag{5}$$

These estimates imply that a one percent increase in either foreign official or foreign private holdings of U.S. Treasuries (as a share of Treasuries outstanding) lowers the term premium by 5 to 6 basis points (or between 17 and 20 basis points per $100 billion inflow). They also suggest that a decline in foreign officials holdings that is offset by an increase in foreign private holdings would leave the term premium roughly unchanged. All told, when we allow foreign private investors to react endogenously to the yield changes induced by an exogenous shock to foreign official holdings, the effects of foreign official flows on the term premium are dampened.

Note that all three variables are endogenous but $\widehat{FPVT}_t$ does not respond directly to deviations in the long relation because the estimate of α_3 is not different from zero. The long-run relation suggests that an increase in foreign holdings of U.S. Treasury securities lowers the term premium, regardless of whether the increase is undertaken by foreign official holders or by foreign private investors.

4 Foreign Holdings and Realized Excess Returns

So far the analysis has focussed on the effects of foreign official inflows on the term premium, which is an ex-ante and model dependent measure of the risk premium. In this section, we examine the effects of foreign inflows on (ex-post) realized excess returns, which is not model dependent. We estimate 2SLS regressions using the same instrumental variables as in the term-premium regressions. All flow variables are expressed as sums during the 1-year holding period ending at time t. So in contrast to the short-run estimates derived earlier from regressions using monthly flow data, the effect we are estimating here is a medium term elasticity. Our a-priori hypothesis is that foreign official inflows during the holding period would increase excess returns by raising the price (or lowering the yield) of the 6-year bond when it is sold as a 5-year bond at the end of the holding period.

The first column of table 6 shows the OLS estimates for the variables measured in levels. The coefficients on foreign official and foreign private flows are positive but not statistically significant. In the column 2, we perform 2-stage least squares using Japanese foreign exchange interventions to instrument for foreign official flows. The second stage coefficient on foreign official inflows is 0.582, and it is significant at the 5 percent level. The coefficient on foreign private inflows is similar in magnitude, and also statistically significant. In order to convert the coefficient estimate of 0.595 into an equivalent effect on the 5-year yield, we let $D^n_{t+1} = 0.595$ in equation 2, and solve for the price of the 5-year bond at the end of the holding period (P^{n-1}_{t+1}) while holding the price of the 6-year bond at the beginning of the holding period (P^n_t) and the one-year rate constant. Doing so, we obtain that a 1 percentage point increase in foreign official flows into U.S. Treasuries notes and bonds over a one-year period (as a share of outstanding notes and bonds) lowers the yield on the 5-year bond at the end of that year by 12 basis points. Thus, if foreign official inflows into Treasury notes and bonds had been $100 billion higher than they were in the one-year period ending in June 2007, the 5-year Treasury yield would have been 42 basis points lower. The p-value associated with the Cumby-Huizinga test statistic suggests that the residuals are autocorrelated, which is why we report Newey-West HAC standard errors. To address the autocorrelation problem explicitly, we try estimating the short-run effect by re-estimating the regression using first differences of the variables (columns 4 and 5). The coefficient on foreign official inflows is still positive and of similar magnitude to the one in column 3, but is no longer statistically significant. This suggests that the short-run and medium-run elasticities may be similar to each other.

As a robustness check, we estimate the excess returns regression using different combinations of instruments. The results are shown in table 7. The instruments pass the weak instruments test in specifications 1 and 2 only. The coefficients on foreign official inflows in these specifications imply that a $100 billion increase in foreign official inflows into Treasury notes and bonds during the one-year period ending in June 2007 would have lowered the 5-year Treasury yield by 39 to 62 basis points.

5 Comparison with other studies

Table 8 compares the effects implied by our estimates to those obtained in other studies. The metric used is basis points per $100 billion in purchases. The top portion of the table compares estimates of the short-run effects, derived from regressions using weekly or monthly data on foreign official flows, or from event studies of interventions by the Japanese ministry of Finance, and the Fed's purchases of Treasuries through the Large-Scale Asset Purchase (LSAP) program. Our short-run elasticity estimates of roughly -50 basis points are roughly in line with those of the other studies. In some cases, the similarity in the estimates may be pure coincidence. For example, McCauley and Jiang (2004) regress 5-year and 10-year Treasury yields on weekly changes in foreign official holdings held in custody at the New York Fed. They acknowledge that their results are "not very robust" to changes in methodology because "widening the regression window to 52 weeks results in less reliable estimates." More importantly, McCauley and Jiang (2004) find a stronger relationship between the previous week's change in yields and the current week's change in custody holdings, suggesting that the direction of causation may well go from yields to flows. In contrast, Bernanke, Reinhart, and Sack (2004) and D'Amico, Kim, and Wei (2010) implicitly control for the joint endogeneity of yields and flows because they estimate the effects of interventions on yields during a narrow time window surrounding the interventions.

The estimates of the medium-term effects of foreign official flows on yields are derived from regressions using rolling sums of 12-month flows. In the previous section, using excess returns regressions we estimate that $100 billion in foreign official inflows during a 12-month period lower the 5-year yield by about 40 to 60 basis points. These estimates are similar to our short run elasticities. Warnock and Warnock (2009) find a similarly large effect, whereas Rudebusch, Swanson, and Wu (2006) find no significant effect. However, as documented by Beltran, Kretchmer, Marquez, and Thomas (2010), the results in these studies are not robust to minor changes in specification.

The long-run elasticities shown in the bottom portion of table 8 are derived from regressions using holdings by foreign official investors, or cumulated purchases by the Fed through the LSAPs. Our estimates from the cointegration analysis are a bit higher than those of Bertaut, DeMarco, Kamin, and Tryon (2011) which regress nominal Treasury yields on the level of foreign holdings. A possible explanation for this difference is that Bertaut, DeMarco, Kamin, and Tryon (2011) treat the level of foreign official holdings as exogenous, whereas we allow it to respond to yields and other factors.

Our long-run estimates are also higher than those of the studies examining the efficacy of the LSAPs (Gagnon, Raskin, Remache, and Sack (2011), D'Amico and King (2011), and

Hamilton and Wu (2011)).[15] There are several reasons for why the Fed LSAP purchases could, at least in theory, have a smaller impact on interest rates than foreign official purchases. First, the Fed's LSAP program was designed as a temporary stimulus program, and announced as such. In contrast, because foreign exchange reserves have steadily grown over the last couple of decades, purchases of U.S. Treasuries by foreign official investors are more likely to be perceived as permanent. Also, surveys of inflation forecasts show an increase in the dispersion of the forecast means around the time the LSAPs came into effect (figure 11), suggesting an increase in inflation uncertainty. If the LSAPs increased the amount of uncertainty surrounding the level of future inflation, the inflation risk premium would have risen, exerting upward pressure on long-term interest rates.[16] In contrast, foreign official purchases of Treasuries are not likely to influence the inflation risk premium. Finally, there are some difficulties with gauging the effects of the the LSAPs using event studies that try to measure the reaction of yields within specific LSAP announcement windows (e.g. Gagnon, Raskin, Remache, and Sack (2011)). If investors had already formed expectations of purchases prior to the announcement window, the response of yields may have occurred prior to the announcement window, and thus would not be captured in the announcement effect. Conversely, a portion of the LSAP effect may only be priced when the purchases actually occur (after the announcement window), as evidenced by the "flow effect" analysis of D'Amico and King (2011). In sum, these conceptual and methodological issues could explain why our estimates are higher than those of the LSAP event studies.

6 Conclusions

Previous studies that have tried to estimate the effect of foreign official inflows on U.S. long-term interest rates have failed to take into account the endogeneity of these inflows. We find strong evidence that foreign official inflows into the United States respond to such things as implied volatility of U.S. and German sovereign bonds, liquidity premium between on-the-run and off-the-run Treasury notes, the U.S. federal government's structural budget balance, and the implied volatility of the S&P500 stock market index, which serves as a proxy for investor risk aversion. When we treat foreign official inflows as an endogenous regressor, the estimated effect of these inflows on yields becomes stronger (more negative). One reason for this is that periods of high investor risk aversion are usually associated with strong private inflows into U.S. Treasuries, lower Treasury yields, and a stronger dollar. In turn, a stronger dollar alleviates

[15] For a more comprehensive list of LSAP studies, see Williams (2011).

[16] Gagnon, Raskin, Remache, and Sack (2011) use a survey-based measure of inflation forecast dispersion to try to control for this in their term-premium regressions.

the pressure on emerging economies to intervene to prevent their currencies from appreciating, reducing foreign official inflows. In sum, sharp increases in investor risk aversion usually result in slower official inflows together with falling yields. Therefore, a model that treats foreign official inflows as exogenous will associate lower yields with slower official inflows in periods of high investor risk aversion, dampening the estimated overall effect of official inflows on yields.

We find that a $100 billion increase in foreign official inflows into U.S. Treasury notes and bonds lowers the 5-year yield by roughly 40 to 60 basis points in the short run. However, our VAR analysis shows that in the long-run, when we allow foreign private investors to react to the effects induced by a shock to foreign official holdings, the estimated effect is roughly -20 basis points per $100 billion. Putting these results into context, between 1995 and 2010 China acquired roughly $1.1 trillion in U.S. Treasury notes and bonds. A literal interpretation of our long-run estimates suggests that if China had not accumulated any foreign exchange reserves during this period, and therefore not acquired these $1.1 trillion in Treasuries, all else equal, the 5-year Treasury yield would have been roughly 2 percentage points higher by 2010. This effect is large enough to have implications for the effectiveness of monetary policy.

Our estimates can be used to gauge the overall effect of the global savings glut on U.S. yields through high foreign savings that are invested in U.S. Treasury securities by the official sector. In other words, if countries stop accumulating reserves and as a result no longer invest in Treasuries, our estimates could be used to gauge the effect on Treasury yields. But our results should not be used to gauge the effect on Treasury yields if a large holder of U.S. Treasuries (such as China) were to shift its reserves away from U.S. Treasuries into say, German Bunds. Such re-allocation of reserves would likely put downward pressure on Bunds yields which, through private sector rebalancing, would in time put downward pressure on Treasury yields as well. Estimating this diversification effect would likely involve estimating a global portfolio balance model using time-series data on the composition of foreign exchange reserves and global cross-border flows, which are not publicly available. Given that there is ample evidence to suggest that reserves diversification is already taking place (see figure 12, for example), this is an important question for future research.[17]

[17]More recently, reserve holders have been diversifying their foreign exchange reserves away from dollar-denominated assets. Even after adjusting for exchange rate effects, the dollar share of foreign exchange reserves reported in the IMF COFER database has been gradually declining (left panel of figure 12). As shown in the right panel of figure 12, we estimate that since 2009 China appears to be diversifying its foreign exchange reserves by allocating a smaller share of newly acquired reserves into U.S. assets.

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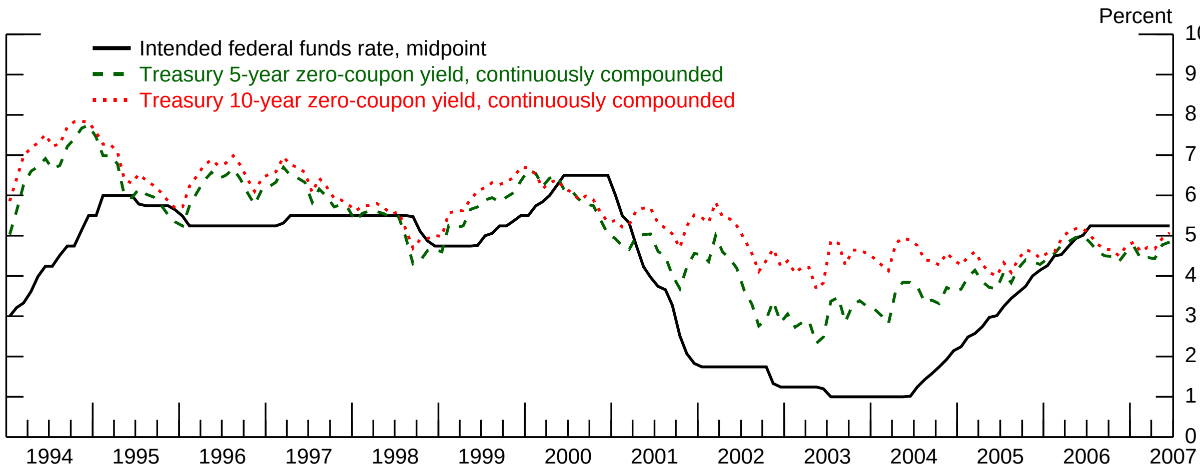

Figure 1: Federal funds rate and Treasury yields.

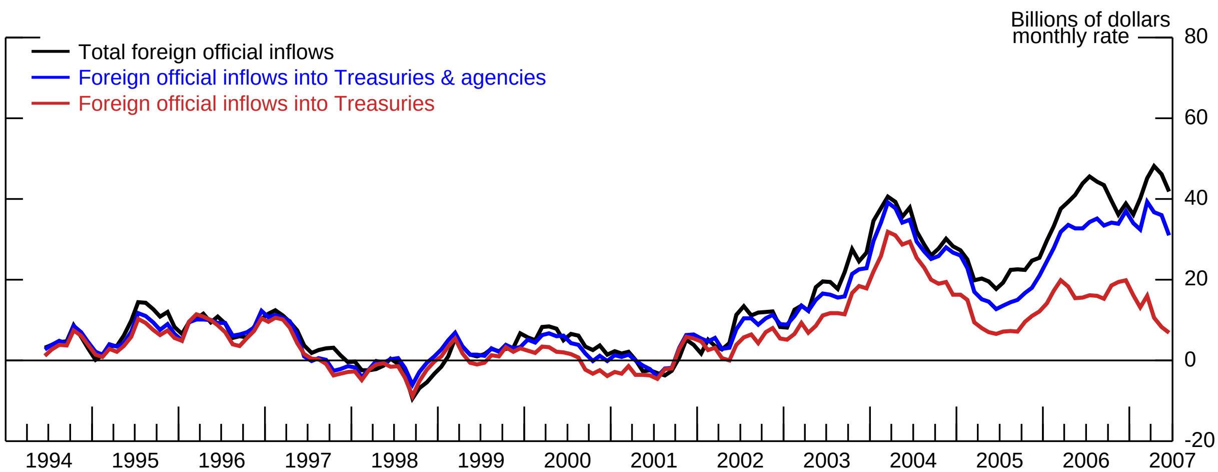

Figure 2: Foreign official inflows into Treasury and agency securities, expressed as a 6-month moving average.

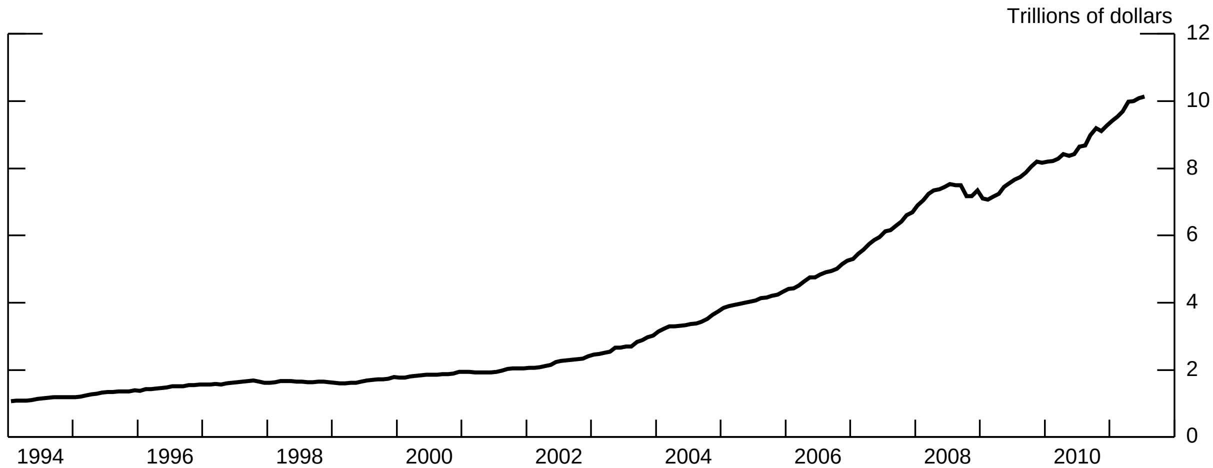

Figure 3: Global foreign exchange reserves. Source: IMF.

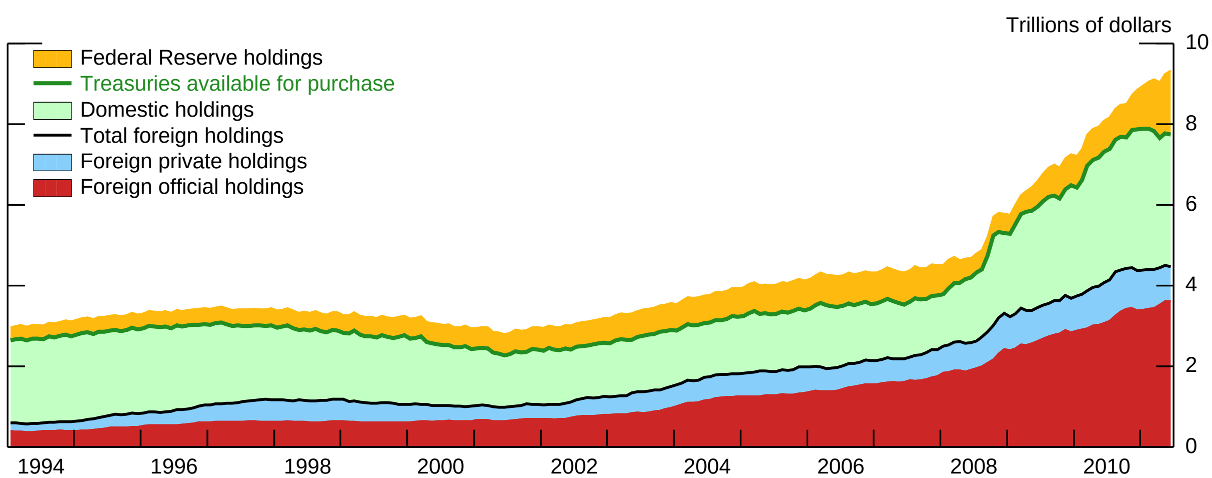

Figure 4: Supply and demand for U.S. Treasury securities.

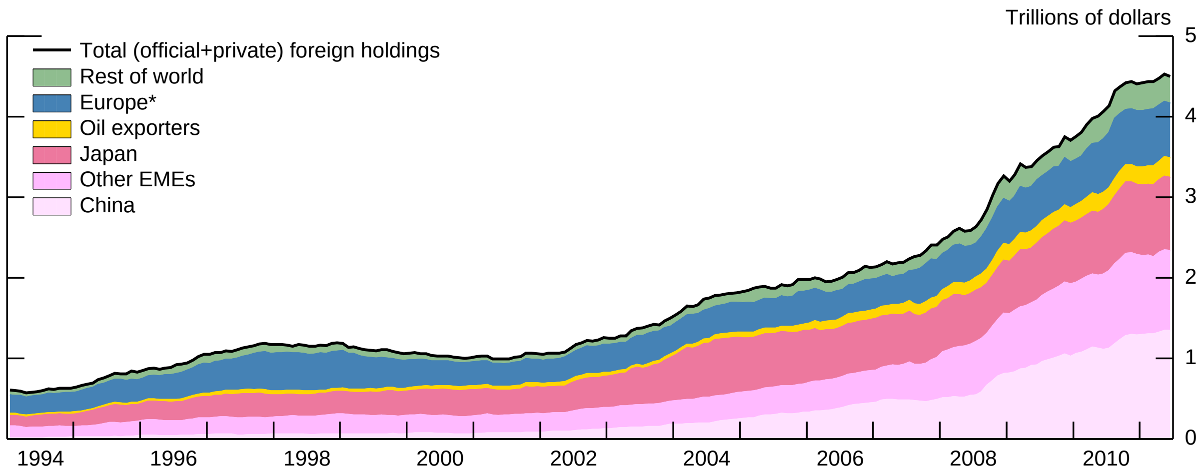

Figure 5: Geography of foreign holdings of U.S. Treasury securities.

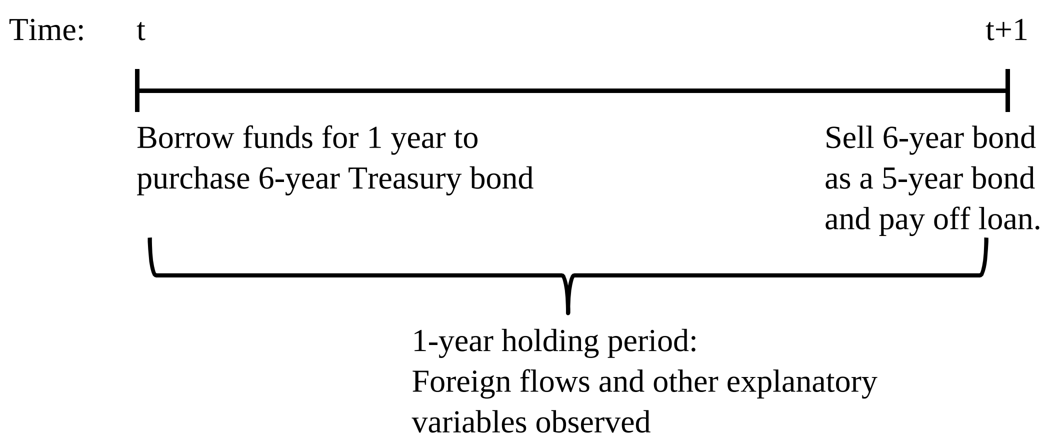

Figure 6: Excess returns realized at time $t + 1$.

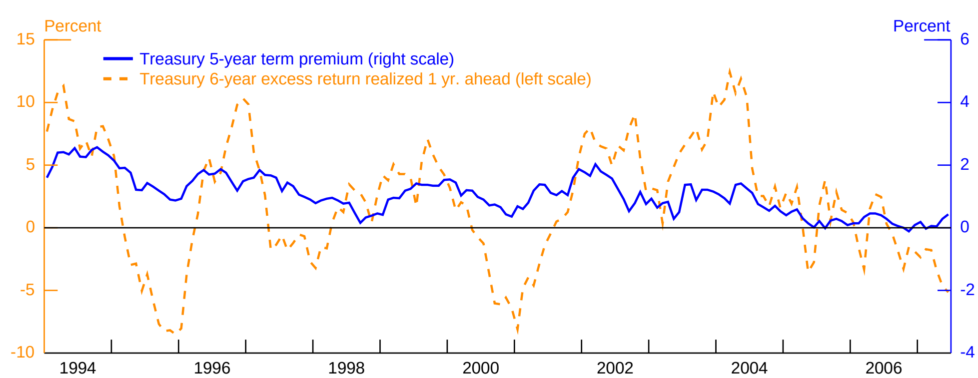

Figure 7: 5-year term premium and future realized excess returns.

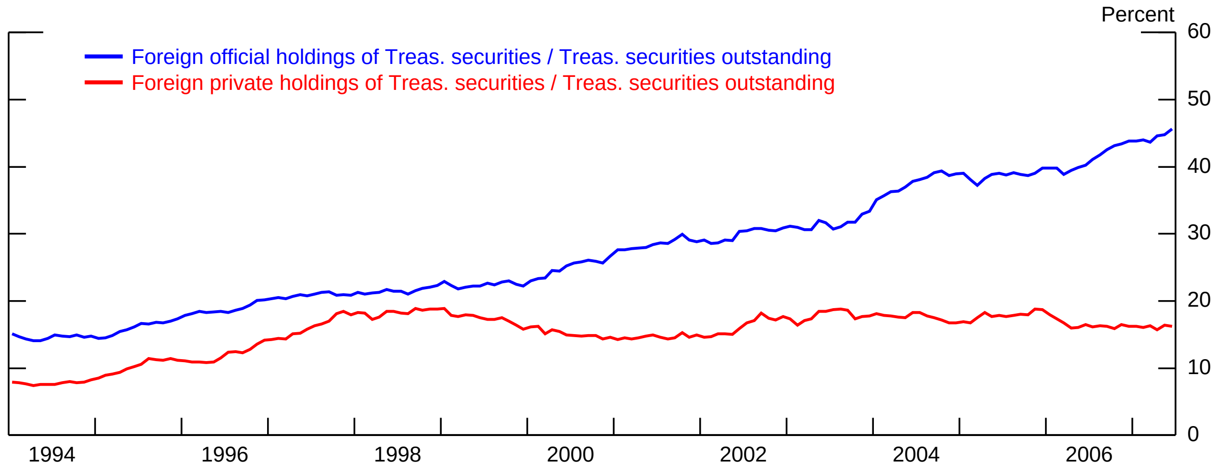

Figure 8: Foreign official and foreign private holdings of U.S. Treasury securities as a share of Treasury securities outstanding.

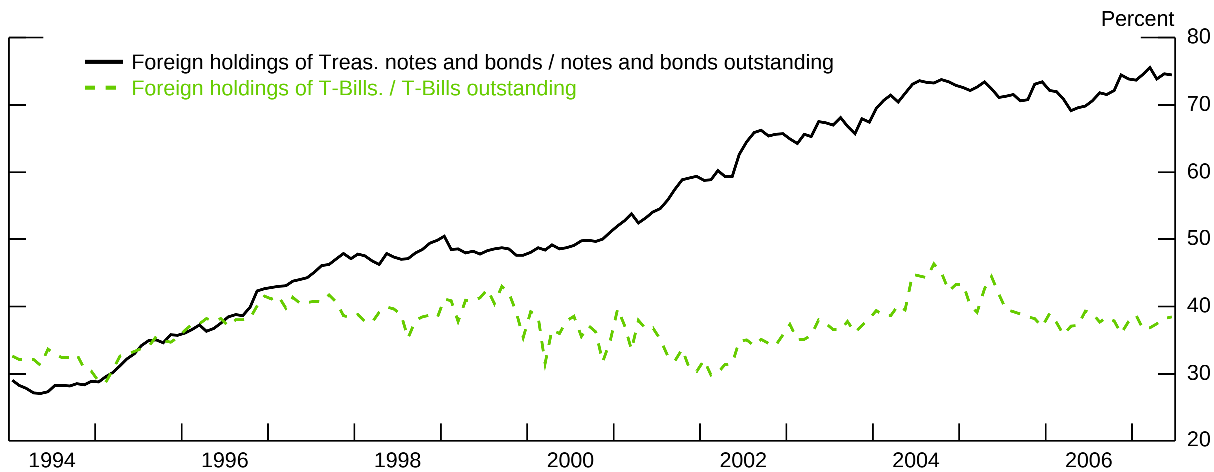

Figure 9: Foreign holdings of long-term (notes and bonds) and short-term (bills) as a share of these respective securities outstanding.

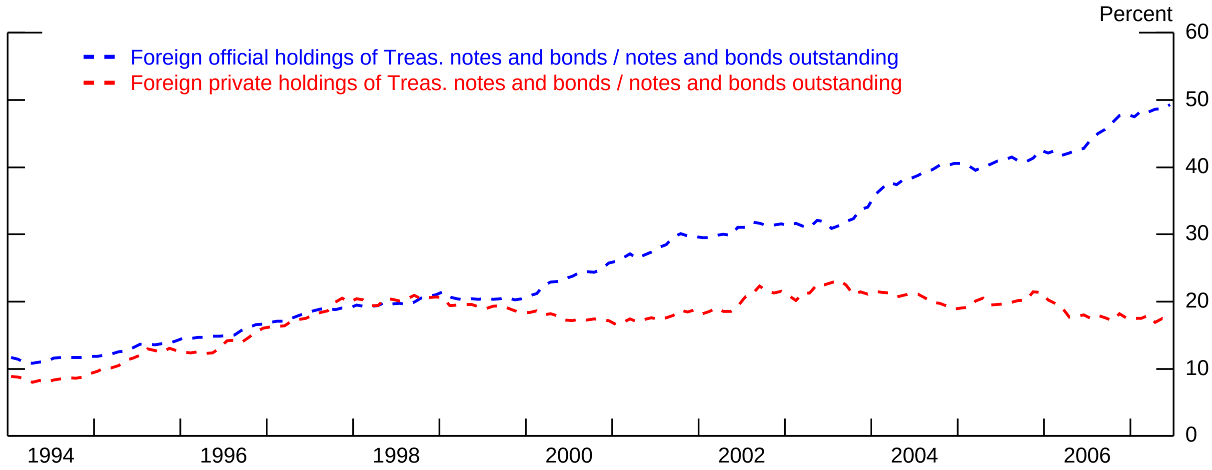

Figure 10: Foreign official and foreign private holdings of Treasury notes and bonds as a share of Treasury notes and bonds outstanding.

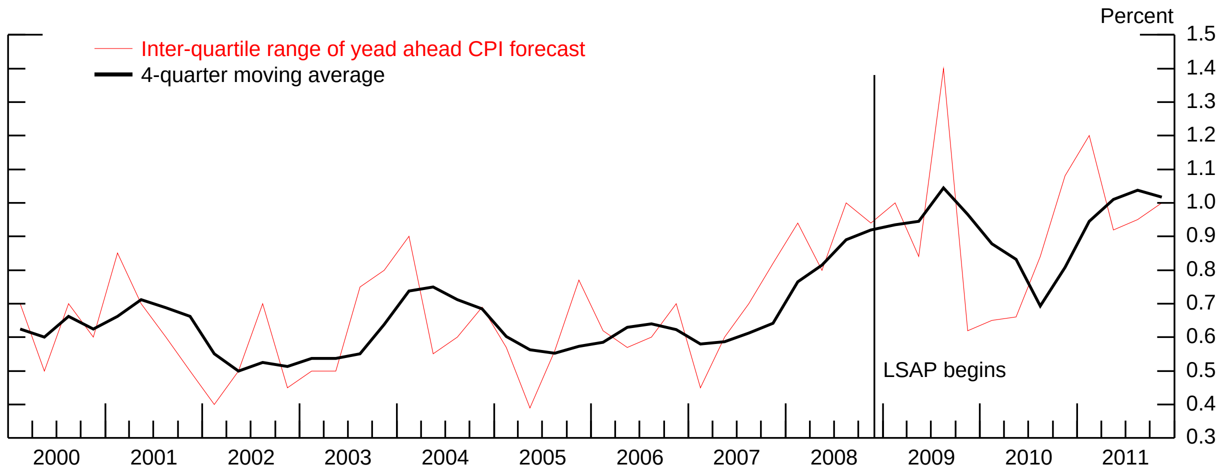

Figure 11: Inflation uncertainty as measured by the dispersion of forecasts for year-ahead CPI inflation. Source: Survey of Professional Forecasters.

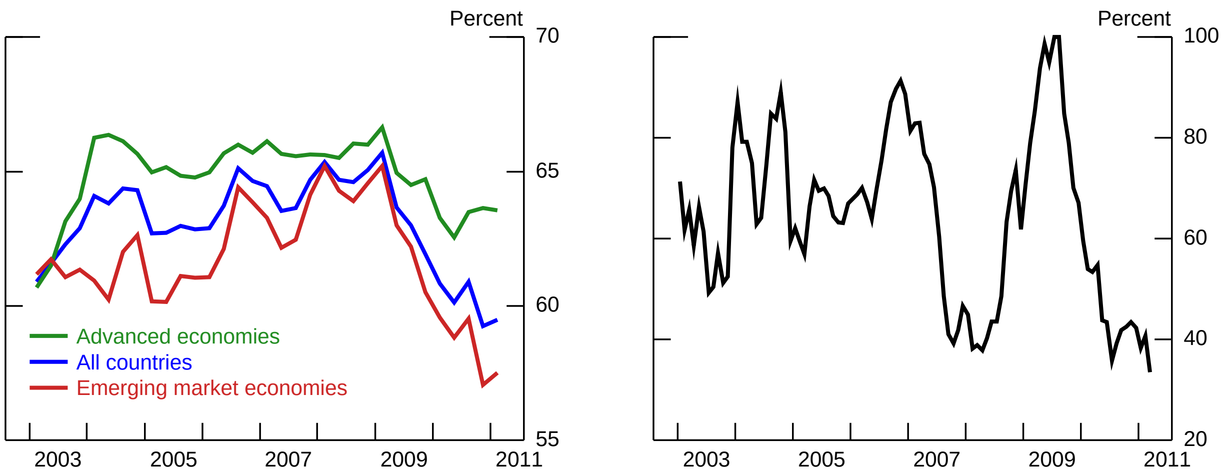

Figure 12: *Left panel:* Dollar-denominated share of foreign exchange reserves. Estimates based on COFER data adjusted for unallocated reserves and with non-dollar reserves valued at 2011-Q1 exchange rates. *Right panel:* Estimated U.S. share of Chinese new foreign exchange reserve accumulations. Authors' estimates based on CEIC, Peoples Bank of China, COFER, IFS, and Treasury International Capital Data.

Table 1: *Term premium regressions*

	(1)	(2)	(3)	(4)	(5)
	OLS:	IV: 1^{st} Stage	IV: 2^{nd} Stage	IV: 1^{st} Stage	IV: 2^{nd} Stage
	ΔTP_t	$\Delta FOI_t / DEBT_{t-1}$	ΔTP_t	$\Delta FOI_t / GDP_{t-1}$	ΔTP_t
Flow Variables					
$\Delta FOI_t / DEBT_{t-1}$	0.052*		-0.135**		
	(0.030)		(0.061)		
$\Delta FPVT\ / DEBT_{t-1}$	0.046**	-0.026	0.041		
	(0.021)	(0.052)	(0.027)		
$\Delta FOI_t / GDP_{t-1}$					-0.696**
					(0.343)
$\Delta FPVT\ / GDP_{t-1}$				0.017	0.182*
				(0.053)	(0.110)
Control Variables					
ΔIP_t^{yoy}	0.025*	0.005	0.027*	0.000	0.026*
	(0.013)	(0.033)	(0.014)	(0.008)	(0.015)
ΔIP_{t-1}^{yoy}	-0.033**	0.010	-0.033**	0.004	-0.031**
	(0.013)	(0.033)	(0.015)	(0.008)	(0.015)
ΔVIX_t	-0.007**	-0.017**	-0.010***	-0.004**	-0.011***
	(0.003)	(0.007)	(0.003)	(0.002)	(0.003)
ΔVIX_{t-1}	-0.001	-0.017**	-0.005	-0.004***	-0.005
	(0.003)	(0.007)	(0.003)	(0.002)	(0.003)
ΔUS_VOL_{t-1}	0.019	0.018	0.018	0.006	0.021
	(0.020)	(0.052)	(0.022)	(0.012)	(0.022)
ΔDE_VOL_t	0.011	-0.056	0.006	-0.015	0.003
	(0.026)	(0.068)	(0.028)	(0.016)	(0.030)
$\Delta STR\_BUDGET\_BALANCE_t$	0.089**	-0.235**	0.023	-0.042*	0.020
	(0.040)	(0.101)	(0.042)	(0.023)	(0.043)
$\Delta LP5_{t-1}$	-0.005	0.002	-0.004	0.000	-0.005
	(0.004)	(0.010)	(0.004)	(0.002)	(0.004)
$OIL\_DEMAND\_SHOCK_t$	0.010	-0.026	0.005	-0.006	0.004
	(0.010)	(0.026)	(0.011)	(0.006)	(0.012)
$\Delta CP^{1\text{-}5}_{t-1}$	0.035*	-0.058	0.025	-0.014	0.022
	(0.020)	(0.051)	(0.024)	(0.012)	(0.025)
$\Delta CP^{6\text{-}9}_{t-1}$	0.018***	-0.010	0.016**	-0.002	0.016**
	(0.006)	(0.015)	(0.006)	(0.004)	(0.007)
Instruments					
$JPYFXINT_t$		0.016***		0.003***	
		(0.003)		(0.001)	
$OIL\_SUPPLY\_SHOCK_t$		0.070		0.016	
		(0.045)		(0.011)	
Observations	160	160	160	160	160
R-squared	0.266	0.447	0.070	0.342	0.013
Durbin-Watson	1.802	1.488		1.441	
Cragg-Donald Wald F-Stat			15.72		9.894
Stock-Yogo critical value, 10%			19.93		19.93
Pagan-Hall Test (P-Value)			0.671		0.789
Cumby-Huizinga Test (P-Value)			0.0159		0.0158
Endogeneity Test (P-Value)			0.0192		0.0339
Hansen J Test (P-Value)			0.3498		0.3147

Notes: Standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. All specifications include a constant and a linear trend.

Table 2: *Alternative instrumental variable specifications for term premium regressions*

	(1) IV: ALL COUNTRIES	(2) IV: ALL COUNTRIES	(3) IV: JAPAN	(4) IV: CHINA	(5) IV: MID-EAST OIL EXPORTERS
First Stage: Instruments					
$JPYFXINT_t$	0.019***	0.019***	0.017***		
	(0.003)	(0.003)	(0.002)		
ΔBOP_CN_t	0.006	0.007		0.006**	
	(0.006)	(0.006)		(0.002)	
$OIL\_SUPPLY\_SHOCK_t$		0.061			0.019**
		(0.051)			(0.008)
Second Stage: Official Flows					
$\Delta FOI_t / DEBT_{t-1}$	-0.140**	-0.145**			
	(0.057)	(0.058)			
$\Delta FOI\_JAPAN_t / DEBT_{t-1}$			-0.147**		
			(0.059)		
$\Delta FOI\_CHINA_t / DEBT_{t-1}$				0.207	
				(0.423)	
$\Delta FOI\_MIDEAST_t / DEBT_{t-1}$					-0.000
					(0.862)
Observations	126	126	160	126	160
R-squared - 2nd Stage	0.106	0.095	0.210	0.305	0.254
Cragg-Donald Wald F-Stat	18.25	12.71	97.59	6.053	6.119
Stock-Yogo critical value, 10%	19.93	22.30	16.38	16.38	16.38
Endogenous Variables	1	1	1	1	1
Exogenous Instruments	2	3	1	1	1
Pagan-Hall Test (P-Value)	0.862	0.890	0.429	0.539	0.545
Cumby-Huizinga Test (P-Value)	0.138	0.127	0.0169	0.387	0.192
Endogeneity Test (P-Value)	0.00932	0.00882	0.0229	0.925	0.408
Hansen J Test (P-Value)	0.9074	0.9013	n.a.	n.a.	n.a.

Notes: Standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. All specifications include the same set of explanatory variables listed in Table 1.

Table 3: *Term-premium regressions using foreign official inflows into both Treasuries and agencies*

	(1) IV: ALL COUNTRIES	(2) IV: ALL COUNTRIES	(3) IV: ALL COUNTRIES
First Stage: Instruments			
$JPYFXINT_t$	0.002***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)
ΔBOP_CN_t		0.004**	0.004**
		(0.002)	(0.002)
$OIL\_SUPPLY\_SHOCK_t$			0.008
			(0.012)
Second Stage: Official Flows			
$\Delta FOI\_TA_t / GDP_{t-1}$	-0.983**	-0.606	-0.637*
	(0.489)	(0.382)	(0.385)
Observations	160	126	126
R-squared - 2nd Stage	n.a.	0.116	0.100
Cragg-Donald Wald F-Stat	7.829	10.29	6.950
Stock-Yogo critical value, 10%	16.38	19.93	22.3
Endogenous Variables	1	1	1
Exogenous Instruments	1	2	3
Pagan-Hall Test (P-Value)	0.850	0.847	0.878
Cumby-Huizinga Test (P-Value)	0.0101	0.201	0.185
Endogeneity Test (P-Value)	0.0433	0.0661	0.0577
Hansen J Test (P-Value)	n.a.	0.3486	0.5437

Notes: Standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. All specifications include the same set of explanatory variables listed in Table 1.

Table 4: *Cointegration Tests*

	12 lags		**10 lags**		**8 lags**		**6 lags**		**4 lags**		**2 lags**		**1 lag**	
Parameters	123		105		87		69		51		33		24	
Log-likelihood	2.7		-15		-30		-41		-52		-73		-88	
SC	4.07		3.67		3.24		2.74		2.25		1.97		1.88	
HQ	2.61		2.43		2.22		1.94		1.66		1.60		1.60	
AIC	1.60		1.58		1.52		1.40		1.26		1.34		1.42	
Residual tests														
Serial Indep.	0.58		0.39		0.74		0.61		0.91		0.10		0.00	
Normality	0.55		0.32		0.70		0.49		0.44		0.04		0.09	
Hetero	0.26		0.20		0.50		0.72		0.36		0.16		0.01	
Rank	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Trace test	55.6	9.19	46.0	7.3	35.6	3.7	30.4	3.54	36.0	6.64	34.1	7.67	24.2	6.82
(p-value)	0	0.35	0	0.55	0.01	0.92	0.04	0.93	0.01	0.63	0.01	0.51	0.2	0.60
Max test	46.4	8.95	38.7	6.82	31.9	3.61	26.9	3.53	29.4	6.17	26.4	6.91	17.3	5.82
(p-value)	0	0.30	0	0.52	0.001	0.89	0.01	0.90	0.00	0.60	0.01	0.51	0.16	0.64
Trace test	42.3	6.99	36.9	5.86	30.1	3.13	26.9	3.13	33.3	6.13	32.8	7.38	23.7	6.7
(p-value)	0.00	0.59	0.01	0.71	0.05	0.95	0.11	0.95	0.02	0.68	0.02	0.54	0.22	0.62
Max test	35.3	6.8	31.1	5.47	27.0	3.05	23.8	3.12	27.1	5.7	25.4	6.65	17.0	5.71
(p-value)	0	0.52	0.00	0.68	0.01	0.93	0.02	0.93	0.01	0.66	0.01	0.54	0.18	0.66

Table 5: *VAR Long-Run Coefficients*

	12 lags	**10 lags**	**8 lags**	**6 lags**	**4 lags**	**2 lags**
Cointegrating vector, β						
Term premium (normalized)	1	1	1	1	1	1
Foreign official	0.046	0.055	0.061	0.062	0.056	0.055
Foreign private	0.061	0.068	0.059	0.05	0.024	0.037
T-stat - cointegration coef.						
Foreign official	5.782	5.939	5.348	4.633	3.803	3.403
Foreign private	2.883	2.758	2.016	1.521	0.676	0.952
Loading Factors, α						
Term premium	-0.481	-0.341	-0.23	-0.21	-0.201	-0.186
Foreign official	-0.54	-0.567	-0.481	-0.295	-0.197	-0.153
Foreign private	0.096	0.214	0.338	0.23	0.14	-0.017
T-stat. - loading factors						
Term premium	-5.831	-5.091	-4.164	-4.559	-5.145	-5.129
Foreign official	-2.378	-3.044	-3.184	-2.288	-1.795	-1.442
Foreign private	0.274	0.776	1.514	1.219	0.849	-0.113

Table 6: *Excess returns regressions*

	(1)	(2)	(3)	(4)	(5)
	OLS:	IV: 1st Stage	IV: 2nd Stage	IV: 1st Stage†	IV: 2nd Stage†
	XR_6_t	$\Sigma_{12}FOI_t / DEBT_{t-12}$	XR_6_t	$\Delta(\Sigma_{12} FOI_t / DEBT_{t-12})$	ΔXR_6_t
Flow Variables					
$\Sigma_{12}FOI_t / DEBT_{t-12}$	0.172		0.595***		0.424
	(0.119)		(0.184)		(0.545)
$\Sigma_{12}FPVT_t / DEBT_{t-12}$	0.656***	0.056	0.616***	-0.036	-0.723***
	(0.144)	(0.067)	(0.137)	(0.053)	(0.251)
Control Variables					
IP_t^{yoy}	-0.942***	0.198	-0.988***	-0.031	-0.282
	(0.330)	(0.154)	(0.317)	(0.074)	(0.328)
IP_{t-1}^{yoy}	0.293	-0.246	0.303	-0.093	0.106
	(0.321)	(0.150)	(0.310)	(0.073)	(0.336)
VIX_t	0.156***	-0.047*	0.175***	-0.019*	0.139***
	(0.057)	(0.027)	(0.044)	(0.011)	(0.049)
DE_VOL_t	-0.361	-0.704***	-0.155	-0.037	-0.730*
	(0.491)	(0.251)	(0.524)	(0.097)	(0.427)
US_VOL_{t-1}	0.026	-0.409***	-0.095	0.073	-0.514*
	(0.315)	(0.155)	(0.300)	(0.069)	(0.312)
$LP5_{t-1}$	0.001	-0.069*	0.040	-0.010	0.035
	(0.081)	(0.038)	(0.084)	(0.015)	(0.070)
$\Sigma_{12} OIL\_DEMAND\_SHOCK_t$	-0.297***	-0.063	-0.261***	-0.010	-0.061
	(0.112)	(0.056)	(0.095)	(0.037)	(0.164)
CP^{1-5}_{t-13}	2.266***	-0.259	2.601***	0.059	-0.147
	(0.380)	(0.176)	(0.428)	(0.068)	(0.294)
CP^{6-9}_{t-13}	0.423***	-0.052	0.395***	0.006	0.048
	(0.143)	(0.067)	(0.144)	(0.023)	(0.111)
$RISK\ APPETITE_t$	-0.494***	-0.050	-0.484***	-0.046	-0.501**
	(0.124)	(0.058)	(0.106)	(0.048)	(0.198)
$\Sigma_{12} STR\_BUDGET\_BAL_t/GDP_{t-12}$	0.168	-0.730***	0.627**	-0.101	-0.549
	(0.310)	(0.145)	(0.284)	(0.182)	(0.892)
Instruments					
$\Sigma_{12} JPYFXINT$		0.025***		0.024***	
		(0.002)		(0.003)	
$\Sigma_{12} OIL\_SUPPLY\_SHOCK_t$		0.239***		0.051	
		(0.057)		(0.040)	
Observations	158	158	158	158	158
R-squared	0.784	0.915	0.765	0.365	0.104
Durbin-Watson	1.326	0.421		1.486	
Cragg-Donald Wald F-Stat			92.79		32.77
Stock-Yogo critical value, 10%			19.93		19.93
Pagan-Hall Test (P-Value)			0.224		0.928
Cumby-Huizinga Test (P-Value)			6.84e-06		0.0970
Endogeneity Test (P-Value)			5.01e-06		0.00374
Hansen J Test (P-Value)			0.3563		0.3902

Notes: Standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. All specifications include a constant and a linear trend. †Explanatory variables in this specification are expressed as first differences.

Table 7: *Alternative instrumental variable specifications for excess return regressions*

	(1) IV: ALL COUNTRIES	(2) IV: ALL COUNTRIES	(3) IV: ALL COUNTRIES
First Stage: Instruments			
$\Sigma_{12} JPYFXINT$	0.026***		
	(0.002)		
$\Sigma_{12} OIL\_SUPPLY\_SHOCK_t$		0.357***	
		(0.079)	
$\Sigma_{12} BOP\_CN_t$			-0.002
			(0.010)
Second Stage: Official Flows			
$\Sigma_{12} FOI_t / DEBT_{t-12}$	0.547***	0.874**	-2.991
	(0.195)	(0.357)	(11.170)
Observations	158	158	115
R-squared - 2nd Stage	0.770	0.732	0.069
Cragg-Donald Wald F-Stat	150.3	20.25	0.0469
Stock-Yogo critical value, 10%	16.38	16.38	16.38
Endogenous Variables	1	1	1
Exogenous Instruments	1	1	1
Pagan-Hall Test (P-Value)	0.157	0.678	1
Cumby-Huizinga Test (P-Value)	7.43e-06	4.46e-05	0.830
Endogeneity Test (P-Value)	0.000294	0.0153	0.549
Hansen J Test (P-Value)	n.a.	n.a.	n.a.

Notes: Standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. All specifications include a constant and a linear trend.

Table 8: *Comparison of estimates of effects of purchases on Treasury yields*

	Basis points per 100 $billion	Investor type	Data frequency
Short-run "flow" effect			
1. This study: Term-premium regs.	-46 to -50	For. Off.	Monthly flows
2. D'Amico and King (2011)	-67	Fed	Daily purchases
3. Bernanke, Reinhart, and Sack (2004)	-66	Jpn. Official	Daily interventions
4. McCauley and Jiang (2004)	-70 to -100	For. Off.	Weekly flows
Medium-run "flow" effect			
1. This study: Excess returns regs.	-39 to -62	For. Off.	12-month flows
2. Warnock and Warnock (2009)	-68	For. Off.	12-month flows
3. Rudebusch, Swanson, and Wu (2006)	no effect	For. Off.	12-month flows
Long-run "stock" effect			
1. This study: Cointegration	-17 to -20	For. Off.	Holdings (level)
2. Bertaut, DeMarco, Kamin, and Tryon (2011)	-11 to -15	For. Off.	Holdings (level)
3. Gagnon, Raskin, Remache, and Sack (2011)	-2 to -5	Fed	Cumulated purchases
4. D'Amico and King (2011)	-10	Fed	Cumulated purchases
5. Hamilton and Wu (2011)	-4	Fed	Cumulated purchases

Note: The numbers reported here are taken directly from the studies and have not taken into account the growth in Treasuries outstanding since the end of the various different estimation samples. Such an adjustment would generally make the effect estimated by older studies smaller.