NBER WORKING PAPER SERIES

FOREIGN INVESTORS AND US TREASURIES

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Working Paper 29313
http://www.nber.org/papers/w29313

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2021,Revised April 2022

The authors thank Daniel Beltran, Carol Bertaut, John Burger, Ricardo Correa, Stephanie Curcuru, Wenxin Du, Chris Gohrband, Robin Greenwood, Kinda Hachem, Arvind Krishnamurthy, Karen Lewis, Gordon Liao, Juan Londono, Hanno Lustig, Jesse Schreger, Annette Vissing-Jorgensen, Veronica Cacdac Warnock, Gwen Yu and Tony Zhang for helpful comments. Warnock thanks the International Finance Division of the Federal Reserve Board for ongoing hospitality. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System. The views expressed herein are those of the author and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 29313
September 2021, Revised April 2022
JEL No. F30,G11,G12

ABSTRACT

We build, from confidential security-level surveys, a novel dataset on the size, flows, coupon payments, and returns of the US Treasuries portfolios of foreign and US investors. The internally consistent dataset provides evidence on foreigners' Treasuries portfolios that sharply contrasts with what is portrayed in the literature. Foreigners do not earn spectacularly low returns; they have higher average annual risk-adjusted returns than US investors (although the differences are well within the bounds of standard confidence intervals), as US investors' strong mean returns are accompanied by higher volatility. Foreigners do not buy Treasuries when they are expensive; dollar-weighted returns that capture the timing and volume of purchases show that both private and official foreigners outperform US investors. And private foreign investors do not have inelastic demand; they are price sensitive, increasing purchases of Treasuries and the duration of their Treasury portfolios when non-US sovereign yields are low or decrease relative to Treasury yields. Our results should inform many literatures, including any that use data on international positions and flows. In fact, an important practical contribution is that the dataset shows which publicly available data on foreigners' flows should (and should not) be used.

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1 Introduction

U.S. Treasuries are arguably the most important securities in the world. They are the benchmark that enables the pricing of a wide variety of loans, not only in the United States (mortgages, corporate bonds, etc.) but also all over the world (e.g., dollar bonds issued by foreign entities). They are the instrument through which one of the most important central banks in the world, the Federal Reserve, conducts its quantitative easing policy and, as such, is one way that U.S. policy is transmitted to the rest of the world. In addition, U.S. Treasury securities are generally acknowledged to be the world's safe asset.

Foreign investors are prominent in the Treasury bond market, holding just over 40 percent of all outstanding Treasuries. And, not surprisingly, foreign investors figure prominently in the academic literature. In Caballero, Farhi, and Gourinchas (2008), emerging market demand for Treasuries depresses U.S. long rates.[1] In the model of Greenwood, Hanson, Stein, and Sunderam (2020), a decrease in foreign bond yields prompts foreigners to purchase U.S. Treasuries. And the notion that foreign investors have poor performance in their Treasury portfolios underlies two influential literatures: Their low returns on U.S. bonds is at the heart of the view that the United States has an exorbitant privilege and their poor timing, poor performance, and inelastic demand are often presented to support the notion that U.S. Treasuries have a sizeable convenience yield.

While foreigners are prominent in the Treasury market and in theoretical and empirical work, we know very little about the nature of their Treasury portfolios, the returns they earn on those portfolios, whether their performance can be characterized as poor, or if their demand can be characterized as inelastic. One reason so little is known about foreigners' Treasury portfolios is that there is no comprehensive benchmark survey of their *purchases* - that is, foreign net purchases of, or flows into, Treasury securities. That, coupled with

[1] Empirical estimates of foreigners' impact on Treasury yields are in Warnock and Warnock (2009), Beltran et al. (2013), and Wolcott (2020), among others.

the fact that there are multiple data sources, means that researchers could easily construct datasets that are not internally consistent.

We build a novel dataset from confidential annual surveys on foreigners' U.S. Treasury portfolios. The dataset has three important features: (i) internally consistent series on positions, flows, coupon payments, and returns, (ii) built from security-level data, and (iii) representing the universe, to the extent we know it (as the positions sum to reported aggregate U.S. statistics). Our study is possible because of a rich security-level dataset on foreign *holdings* of U.S. Treasuries for the period 2003-2019, data from mandatory surveys on foreign portfolio investment in the United States conducted through the U.S. Treasury International Capital (TIC) System that are a primary input for U.S. official statistics.[2] The confidential security-level data include various security characteristics, such as a general security description and identifier, issue and maturity dates, coupon rate, and amount held, but also include both the face (which excludes price change effects) and market values of holdings. In addition, because we also know at the security level the Fed's Treasury portfolio and the entire Treasury market, we can construct as a residual U.S. investors' Treasuries portfolios. In all, our dataset enables security-level analysis and the first-ever direct comparison of foreign and U.S. investors' Treasury portfolios, while also producing survey-consistent aggregate measures of flows, coupon payments and returns.

Equipped with the novel dataset, we first provide a public service by creating survey-consistent flows series that can be used to check the quality of publicly available data. The survey data allow for a straightforward comparison with other sources of *positions* and we find that since 2003 other sources line up with the survey data. But to check data on *flows*

[2]While the security-level data are confidential, various aggregations of positions are made publicly available in annual survey reports (SHL reports): see https://www.treasury.gov/resource-center/data-chart-center/tic/Pages/shlreports.aspx. As TIC survey data are the primary input for the Bureau of Economic Analysis' (BEA) International Investment Position of the United States, when summed our security-level data add up to the official U.S. data as reported by the BEA (and the Federal Reserve's Financial Accounts of the United States, as it relies on BEA's presentation).

requires another step: creating survey-consistent flows. From the survey data we directly, and therefore accurately, compute the security-level flow (i.e., net purchases). Summing the security-level flow produces a survey-consistent aggregate flow measure that can help assess reported flow data, and we show which publicly available data on foreigners' flows should (and should not) be used.

The security-level data allow us to directly compute portfolio returns by investor type. Without the security-level data, computations of investors' Treasury portfolio returns rely on aggregate Treasury bond indices that cannot assess how the *composition* of Treasury portfolios affects returns. For example, if in a particular year foreigners had a higher weight on shorter-term Treasury bonds and those bonds had higher returns than long-dated Treasuries, foreigners' Treasury portfolios would have higher returns.

We investigate the impact of portfolio composition on returns by constructing annual cross-sectional returns built from the weights of four types of Treasury market participants - foreign private and foreign official investors, private U.S. investors, and the Federal Reserve - within the universe of Treasury bonds. The results indicate that returns differences across investors are relatively small and those that exist are driven by risk. Specifically, average annual portfolio returns over the period June 2003 - June 2019 indicate that private foreign investors (3.77 percent per annum) and U.S. private investors (4.34 percent) beat the market (3.59 percent). And while foreign official investors' returns (3.02 percent) were lower than market returns, the gap is only 57 basis points. Differences across investor types appear small and they are: None is statistically different from any other.[3] The differences in average

[3]We note that two Treasury market participants - the Fed and foreign governments - have motivations that differ from private investors'. The Fed does not attempt to maximize returns on Treasuries. As noted by the Federal Reserve Bank of New York System Open Market Account (SOMA) desk (https://www.newyorkfed.org/markets/treasury-reinvestments-purchases-faq): "In general, the Desk seeks to operate in a manner that is relatively neutral to the securities available for purchase and in a way that limits the potential for operations to affect normal market functioning, unless otherwise appropriate for efficient and effective implementation under the directive. As such, purchases of Treasury securities are conducted across a range of maturities and security types in rough proportion to the universe of Treasury securities outstanding." In one period - Operation Twist from September 2011 until June 2012 - the Fed

annual returns are not due to skill/timing (i.e., choosing the right bonds at the right time), as across investors' the differences in yield-to-maturity (YTM) by original maturity bucket are neither meaningful nor persistent differences, except at the very long end of the curve (20-30 years).[4] Rather, returns differences appear to be a function of risk. For example, U.S. investors have a much longer duration Treasury portfolio and this additional risk propelled their returns. In fact, Sharpe ratios (calculated as mean excess returns divided by their standard deviation) indicate that foreign officials' portfolios had higher risk-adjusted returns than private foreign and U.S. investors. That said, as with raw returns, the differences in Sharpe ratios are not statistically different across investor type. Overall, the small differences in average annual returns disappear once we account for risk (as measured by volatility).

Average annual returns, metrics that are also used in the exorbitant privilege literature, are useful but do not capture the timing and magnitude of participants' flows into and out of the Treasury market. To capture how variation in the timing of purchases affect returns investors earn, Dichev and Yu (2011) propose dollar-weighted returns as given by internal rates of returns (IRRs). While strong language on the spectacularly poor performance of foreign investors is prominent in the literature (e.g., Krishnamurthy and Lustig (2019) and Jiang et al. (2021) among others), no study has investigated this using a dataset that is high quality, internally consistent, and comprehensive. In contrast, using the security-level dataset we can build all four components needed to compute investors' Treasury market IRRs: the market value of initial positions (the initial outlay), flows (interim outlays), face

deviated from this by purchasing the long end and selling the short end. Foreign governments have broad objective functions that typically do not include maximizing returns on their Treasury portfolios. Foreign governments' demand for Treasuries are due to the world's main reserve asset's role in countries' reserve management and FX interventions, with motivations often divided into precautionary (building up defenses to reduce the probability of a future crisis), mercantilist (managing the exchange rate), and those that are natural by-products of other goals (e.g., managing inflation, smoothing business cycle fluctuations); see Arslan and Cantu (2019) for a useful discussion.

[4]There is not much mass at the long end. 30-year bonds were not issued by the U.S. Treasury between February 2002 and February 2006 and only about 20 percent of foreign private and U.S. portfolios, as well as the market, are in bonds with 20-30-year original maturity. In 2011, the year of the largest difference in YTMs, long-term bonds were only 4 percent of foreign officials' Treasury portfolios.

value (to which we apply security-specific coupon rates to calculate interim payouts), and the market value of terminal positions (the final payout). We do this for all four investor types, which allows for the first-ever direct comparison of the returns earned by foreign and U.S. investors. Our findings are in direct contrast to notions that foreigners have poor timing and poor performance: Foreigners, both private and official, have higher dollar-weighted returns than U.S. private investors.

Finally, we assess how and if foreigners alter their Treasury portfolios. Is their demand for Treasuries inelastic? In the Greenwood et al. (2020) model, changes in sovereign yields lead to new flows, yet in Krishnamurthy and Lustig (2019) foreigners are price inelastic. We find that private foreigners - who are behind the bulk of foreign purchases the past 5-10 years - have elastic demand for Treasuries, but official foreigners (i.e., foreign governments) do not. We do this in two ways: one on the composition of foreigners' Treasury portfolios, the other on the magnitude of foreigners' flows. We first use the security-level holdings data and show, using country-level regressions of weighted-average duration, that private foreign investors, but not foreign official investors, lengthen the duration of their Treasury portfolios when CIP deviations (the synthetic sovereign dollar yield minus the Treasury yield, which is the opposite of the Treasury basis) decrease. We then turn to a higher frequency (monthly) dataset and show that private foreign investors, but not foreign officials, increase their flows into U.S. Treasuries when CIP deviations are low or have fallen.[5] The analyses of flows and duration provide evidence that private foreign investors, but not foreign officials, have elastic demand for Treasuries.[6]

Our results have implications for many literatures. In terms of what data to use, anyone using U.S. capital flows data, especially on (but not limited to) Treasury bonds, would

[5]We use the publicly available survey-consistent estimates produced in Bertaut and Tryon (2007) and Bertaut and Judson (2014). We refer to these monthly data as BTBJ.

[6]These results are consistent with the finding in Krishnamurthy and Vissing-Jorgensen (2007) that private foreign investors are more price elastic than official investors.

benefit from our assessment of data sources. Recent papers based on data that we show should not be used include Jiang et al. (2021) and He, Nagel and Song (2021). We do not fault the authors of those papers, as until now no such data assessment has been done. There has not been an obvious way for researchers to discern which sources are accurate, because without our survey-consistent flows series it is difficult to make a definitive statement on data quality. In terms of our findings, our security-level and aggregate analyses provide strong evidence that the convenience yield literature should not rely on foreigners having a larger convenience yield than U.S. investors because of poor timing, poor performance, and inelastic demand. We show, in stark contrast to what is portrayed in the literature - see, for example, Krishnamurthy and Lustig (2019) and the convenience yield theory of exchange rates (Jiang et al. (2021)) - that in their Treasury portfolios foreign investors have high risk-adjusted time-weighted returns, high dollar-weighted returns, and similar yields as other investors on similar maturity bonds, and that private foreign investors increase purchases and the duration of their Treasury portfolio when CIP deviations decrease. Yes, foreign officials, with much broader objective functions, appear to be price insensitive. But they do not seem to pay for this, as their annual returns have high Sharpe ratios and their dollar-weighted returns are higher than U.S. investors'. And our work on investors' portfolios in the world's safe asset should inform the dominant currency and exorbitant privilege literatures. On the latter, our work reminds that large within-asset class returns differentials - specifically, on Treasury bonds - do not exist and that any computation of returns differentials must be cognizant of 'other adjustments' embedded in the underlying data series, as shown in Curcuru, Dvorak, and Warnock (2008).[7]

The paper proceeds as follows. In the next section we create survey-consistent flows

[7]The perception that foreigners have low returns on U.S. bonds helped create the notion that the U.S. has an exorbitant privilege. See Gourinchas and Rey (2007, Table 1.1), which reports that for a 30-year period foreigners' annualized real returns on U.S. bonds were 32 basis points (bps), much lower than the 300 bps real returns on Treasury bonds presented for the same period on Aswath Damodaran's NY Stern web site (http://pages.stern.nyu.edu/ adamodar).

and assess the many different sources of data on foreigners' flows into and positions in U.S. Treasury bonds. In Section 3 we present average annual returns on the Treasury portfolios of foreigners and U.S. investors and examine reasons behind the returns differences. In Section 4 we examine dollar-weighted returns. In Section 5 we demonstrate how foreign investors alter their Treasury portfolios in response to changes in yields. Section 6 concludes.

2 Data on Foreigners' U.S. Treasury Portfolios

While there are multiple sources of data on foreigners' purchases of and positions in U.S. Treasury securities, it is difficult for researchers to know which sources are appropriate for addressing a particular question. In this section we present and assess the various sources.

2.1 The Many Data Sources

The main sources are reports by the Treasury Department, BEA, and the Fed. We first discuss the annual security-level holdings data, then higher frequency data on positions and flows.

Security-Level Portfolio Data

The highest quality data are, not surprisingly, reported at the lowest frequency: annual. Since 2003, security-by-security data on foreigners' Treasury portfolios - the amount foreigners hold of each and every Treasury security - are collected annually by the U.S. Department of the Treasury as part of the TIC reporting system.[8] The security-level data underlie the

[8]Griever, Lee, and Warnock (2001) discuss the origins of the TIC system. Briefly, in the early 1970s public concern about the rise in European and Japanese investors' U.S. investments, as well as about the substantial investable sums accumulated by oil-producing countries, prompted the first modern benchmark survey to measure foreign holdings of U.S. long-term securities as of year-end 1974. It was recognized that without benchmark surveys, the TIC system could not accurately identify the countries that were holding U.S. securities or provide much information on the actual securities being purchased. To address these shortcomings, Congress passed the Foreign Investment Study Act of 1974 (Public Law 93-479), which evolved into the International Investment and Trade in Services Survey Act (22 U.S.C. 3101 et seq.). The latter act

annual U.S. TIC surveys of foreign holdings of U.S. securities and feed into official BEA data on the U.S. international investment position (and the Fed's Financial Accounts of the United States data). The main reporters are U.S.-resident custodians (including brokers and dealers), which must report all U.S. securities they hold on behalf of foreign residents (including in their own foreign subsidiaries and affiliates). Given the mandatory reporting, the holdings data are comprehensive; they capture the entire foreign portfolio of U.S. Treasuries at the individual security level.

The security-level data are annual, reported as of June 30 of each year for each foreign country's holdings of each security. The survey data allow us to distinguish between holdings of foreign official institutions (e.g., central bank reserve managers) and holdings of private investors. Data are reported on a resident basis; that is, we observe the direct owner of these investments as reported by the custodians, but not the ultimate owner. In practical terms this means that when we report foreign official and foreign private holdings, the foreign official amount is a lower bound with some official holdings bleeding into the foreign private numbers (for example, if a central bank uses a custodian in, say, Belgium).[9]

We conduct a number of checks. We use security identifiers to match the TIC holdings to security-level information on outstanding amounts from other sources. We use ICE BofA Merrill Lynch U.S. Treasury indices and TreasuryDirect for data on Treasury bond amounts issued and outstanding. We cross check the data on outstanding amounts from these different data sources to make sure we correctly capture security re-openings (when the U.S. Treasury

stipulates, among other things, that a comprehensive benchmark survey of foreign portfolio investment in the United States be conducted at least once every five years and that information collected under the authority of the act be published for use by the general public and by U.S. government agencies. Such surveys were conducted every 5 years from 1974 through 1999 (with the 1999 survey being conducted in March 2000 to avoid possible Y2K complications). Since 2003 the surveys have been conducted annually.

[9]In our analysis in Section 3 we compare foreign official and foreign private investors' returns, yield-to-maturity, and duration of Treasury holdings, so we also report results either excluding Belgium's private holdings or shifting these to the official investors' portfolios. In addition, as discussed in more detail in Section 3, since country attributions are subject to the nationality vs. residency issue studied in Warnock and Cleaver (2003), Bertaut, Bressler, and Curcuru (2019), and Coppola et al. (2021), in our country-level analysis of the security-level holdings we make further adjustments and robustness checks.

issues additional amounts of a previously issued security; the reopened security has the same maturity date and coupon interest rate). We do this for each annual survey from June 2003 through June 2019. To confirm that we have included all bonds, we first sum the holdings and compare to the surveys' published aggregate amounts. They match exactly. We also, from the surveys' prices and payment terms, calculate each bonds' total return, yield-to-maturity, and duration at each end-June date. As the prices and payment terms are the same or very close to the ones reported per security in the constituent files of the BofA Merrill Lynch index, our results are very close if we instead use the BofA Merrill Lynch index security characteristics for the matched securities. The security-level data we use represent the universe, to the extent it is known.

Other Data on Positions

The now annual security-level TIC survey (henceforth TIC SHL), conducted each year as of end-June, is the primary input for two other sources of foreigners' positions in U.S. Treasuries: BEA's International Investment Position, or IIP, data (quarterly since 2006, prior to that year-end) and the Federal Reserve's quarterly Financial Accounts of the United States (formerly known as Flow of Funds (FOF)) Table L.210.[10] Those two sources present very similar numbers for *positions*, as they share a primary input (the TIC SHL survey of foreigners' holdings of U.S. securities). As Figure 1 (top panel) shows, since the SHL surveys became annual (in 2003), there are no discrepancies between these series. Two of these sources - the annual TIC survey and BEA's IIP - also provide a split between foreign official and private foreign investors.[11] Those two sources are in agreement not only on the overall amount of foreign holdings, but also on the split between official and private investors (Figure 1, bottom panel). There are minor differences - BEA puts a little more in private holdings,

[10]BEA's IIP data is at https://www.bea.gov/data/intl-trade-investment/international-investment-position. In the remainder of the paper we use FOF to refer to the Financial Accounts of the United States data; FOF is at https://www.federalreserve.gov/releases/z1/.

[11]Prior to a comprehensive revision in 2014, FOF provided such a split in its main presentation.

because it moves holdings of international and regional organizations to private - but data on foreigners' holdings of U.S. Treasuries are pretty similar regardless of the source. This makes sense because aggregations from the annual security-level TIC SHL are the primary inputs into the others, so minor differences arising only when a source creates estimates at a frequency higher than annual or when a source publishes data prior to the release of the annual survey data. But, because each source recognizes that the TIC SHL is the most comprehensive and accurate measure of foreign holdings of U.S. securities, differences tend to be small and short-lived.[12]

Flow Data

While sources of holdings data are in agreement, data on foreigners' net purchases of Treasuries can vary substantially by source. Transactions data, or foreigners' net purchases of U.S. Treasury bonds, are published by the same sources but the data are collected in a different manner. There is no comprehensive security-level *transactions* survey; the TIC SHL *holdings* surveys obtain positions data from global custodians, but there is no equivalent for data on transactions (i.e., flows). TIC S monthly transactions reports survey broker dealers and banks, but it has long been recognized that there are issues with the TIC S transactions data. Thus, each source must decide how to estimate net foreign purchases. Since 2013 BEA imputes transactions from the reported TIC positions (annual TIC SHL surveys and monthly SLT data); prior to 2013, TIC S flows were the main source for BEA transactions data. BEA's presentation is, in turn, the official source for FOF.[13]

Figure 2 (top panel) shows that BEA's BOP and the Federal Reserve's FOF are identical - it is barely discernable that the lines differ - but that TIC S flows differ substantially. For

[12]Since 2012 TIC monthly holdings data, the SLT, are available and used as an additional input to the BEA IIP and FOF published data. We do not analyze these data since these positions are collected at an aggregate level and are similar to the aggregated SHL annual data.

[13]Note that in FOF tables all flow series are seasonally adjusted, but unadjusted series are also available. BEA does not seasonally adjust portfolio flows, and our analysis in this section uses unadjusted series. For more details on the relationship between BEA and TIC S flows, see Bureau of Economic Analysis (2019).

some years TIC S flows exceed flows presented by the other sources, but since 2012 TIC S flows have been far below the others. Moreover, the split between official and private foreign flows is dramatically different (Figure 2, bottom panels). As FOF no longer presents this split, we focus on TIC S and BEA's BOP. BEA BOP data (Figure 2, bottom left) show that through 2012 the bulk of foreign flows into U.S. Treasury bonds were from official investors, whereas TIC S (Figure 2, bottom right) suggests that private flows have exceeded official flows every year. The difference between TIC S and the other sources is vast. Since 2003 private foreign flows into Treasury bonds are $1.6 trillion greater in TIC S than in BEA's BOP data.

2.2 An Assessment

Researchers are confronted with a number of series on what is ostensibly the same thing - foreigners' purchases of Treasury bonds - and have no obvious way to discern which is most accurate. While there are official descriptions of each measure, an outsider might find it difficult to judge how to use the data.[14] But there is a direct way to ascertain which series should be used, albeit one that is only available since 2003. The comprehensive security-level annual surveys of foreigners' holdings is the single most accurate source. Other agencies seem to agree; recall from Figure 1 on holdings data that no series deviates from the annual survey amount. The problem for the researcher is that annual holdings data do not easily translate into flow series.

We can assess flows data sources by creating implied flows from the TIC SHL surveys. The confidential security-level data from the comprehensive annual surveys include various security characteristics, such as a general security description and identifier, issue and maturity dates, coupon rate, and amount held. The data also include both the face (which

[14]See, for example, the TIC FAQ page (https://www.treasury.gov/resource-center/data-chart-center/tic/Pages/ticfaq1.aspx), as well as Bertaut and Judson (2014).

excludes price change effects) and market values of holdings. Armed with those we can accurately calculate the valuation change on each and every U.S. Treasury bond and then the security-level flow is directly (and easily) computed as the change in the position (which is observed) less the valuation adjustment (which is directly computed).

We do this for each annual survey from June 2003 through June 2019. To confirm that we have included all bonds, we first sum the holdings and compare to the surveys' published aggregate amounts. They match exactly. Confident that we have every bond, we then sum the flows; we will call the flows calculated from the security-level holdings and calculated valuation changes *implied flows*. As Figure 3 (top panel) shows, our implied flows differ greatly from TIC S flows and are closest to the BEA and FOF flow series, although in certain years, such as 2005 and 2018, the gap is sizeable. The evidence suggests that researchers should use either FOF or BEA (which are identical).[15]

We then turn to the split of foreign holdings into those by governments (i.e., foreign official holdings) and those by private foreign investors. FOF no longer presents this split, so the comparison here is between our implied flows and the BEA and TIC S series (Figure 3, bottom panel). The BEA series and our implied flows are very similar for the foreign official and foreign private flows, with a material deviation only in 2016 when the BEA series has more official and less private flows (but the same total). TIC S flows - used in Jiang et al. (2021) and He, Nagel and Song (2022), among others - differ substantially from our implied flows and BEA-reported flows.

Figure 4 brings in another source. For the past two decades the Federal Reserve's International Finance Division has used the high-quality but infrequent positions surveys to improve flow data and create internally consistent monthly dataset on positions, flows, and valuation

[15]That the TIC S flow data, soon to be discontinued (Federal Register Vol.86, No.104, 2021: https://ticdata.treasury.gov/resource-center/data-chart-center/tic/Documents/frnslt2022(6-2021).pdf), should not be used has been recognized for at least two decades; see Griever, Lee, and Warnock (2001). Warnock and Cleaver (2003) noted significant problems with the TIC data on U.S. bonds. Many of TIC S problems pertain to bilateral flows, but there have been substantial issues with aggregate flows too.

adjustments (Thomas, Warnock, and Wongswan (2004), Bertaut and Tryon (2007), Bertaut and Judson (2014)); we call these data BTBJ (for Bertaut Tryon, Bertaut Judson). For Treasuries the aggregate series for private and official foreign investors are currently available starting December 1979; country-level estimates are available starting December 1984. As Figure 4 shows, BTBJ positions are identical to SHL and FOF positions (top panel), and BTBJ flows are nearly identical to survey implied flows but differ a bit from FOF flows (bottom panel). For historical data series available at the monthly frequency, the Bertaut and Tryon (2007) and Bertaut and Judson (2014) BTBJ data provide a publicly available internally consistent series on positions, flows, and valuation adjustments.[16]

To summarize, holdings data are very similar across all data sources, but flow data can vary substantially. For current flows estimates, researchers should not use TIC S data and instead should turn to the quarterly BEA data or the unadjusted FOF data. For historical (monthly) time series, researchers should use the Bertaut and Tryon (2007) and Bertaut and Judson (2014) BTBJ data.

Note though that the quality of BTBJ data may well vary through time, as it is a function of the frequency of the underlying security-level surveys that provide the methodology's important fixed points for the positions. That is, when security-level surveys were conducted approximately every five years (1974 - 2000) the BTBJ data, while the best available for that time period, are likely lower quality than when the surveys have been conducted more frequently (annually since 2003). In addition, the monthly aggregate-level data collection on positions (the SLT), which began in 2012, might further increase data quality.

[16]In Section 4 we are more exact about the term internally consistent, which concerns the so-called other adjustments that are embedded in other datasets. Vissing-Jorgensen (2021) also highlights the importance of using the best data series on Treasury holdings and flows, showing that during the pandemic shock of 2020Q1, BTBJ data indicate that foreign official sales exceeded foreign private sales, but TIC S data do not.

2.3 What the Data Show

For the rest of the paper we bring in Fed holdings of (and flows into) Treasuries, as well as U.S. investors' (constructed as a residual). Federal Reserve Bank of New York SOMA data provide the Fed's Treasury holdings at the security level. Armed with foreign holdings and the Fed's positions, and knowing the universe of all marketable Treasury bonds outstanding, we calculate U.S. investors' holdings as the residual: total outstanding less foreign and Fed holdings.

For much of the past two decades, foreigners as a group have had the largest Treasury bond holdings (Figure 5, top graph). Their holdings, as a share of all marketable Treasury bonds outstanding, has mostly fluctuated between 40 and 50 percent, reaching a high of 58 percent in 2008. Over this period Fed holdings were often just below 20 percent of the market, with a noticeable sharp deviation from that during QE1 (when the Fed shifted its portfolio toward other securities like mortgage-backed securities) and a slow decline 2015-2019. U.S. investors' holdings, which we calculate as the residual, have fluctuated between 30 and 40 percent of the Treasury market over the past two decades. Within the set of foreign investors, foreign officials' Treasury holdings are about twice as large as private foreigners. That said, since 2012 foreign officials' holdings have been largely flat (Figure 1, bottom graph), mimicking global international reserves (which peaked in 2014Q2 and did not reach that level again until 2020Q3), while foreign private positions have been steadily increasing. As a result, as a percent of the expanding Treasury market, foreign official has steadily fallen and foreign private has increased a bit (Figure 5, bottom graph).

Turning to the associated flows, which for readability we depict in Figure 6 as 3-year moving sums, foreigners were the largest source of flows until 2016, when U.S. investors' flows began increasing and exceeding foreign flows. Fed purchases peaked 2011-2013 with the initial QE programs and by 2017 were zero or negative. Within foreign flows (Figure 6, bottom graph), every year since 2014 private foreign purchases of Treasuries have exceeded

officials' purchases.

3 Security-Level Treasury Bond Portfolios

We next turn to three applications that are at the heart of much recent work on Treasury bonds: the average annual returns foreigners earn on their Treasury portfolios, dollar-weighted returns that take into account the timing of new purchases, and how (and if) foreigners alter these portfolios.

We start with an examination of average annual returns that is based on the composition of security-level Treasury portfolios, an exercise that is analogous to the analysis of average annual returns in the exorbitant privilege literature: compute annual returns the best way possible and then compare average annual returns across investor types. It is inherently a (simple annual average of a) cross-sectional analysis that addresses the following question: Did the actual Treasury securities held by different investor types have higher or lower than average (e.g., market) returns?

3.1 Average Annual Returns

We use the security-level data to observe, as of each June 30th since 2003, the portfolios of private and official foreign investors. For completeness, we also report results for the Treasury portfolios of the Fed - although the Fed does not attempt to maximize returns on Treasuries and its motivation in buying Treasury securities is quite different from other investors' - and U.S. investors. With those portfolios, and assuming investors reallocate on June 30th of each year (the day we observe foreign portfolios), we can compute annual returns for each type of investor.[17]

[17]Our dataset is of holdings of Treasury bonds. It does not include other instruments, such as derivatives and repos, through which investors can earn returns on Treasuries.

We follow standard returns index construction methodology to compute returns. In index construction, the returns of each bond are typically weighted by the relative size of the bond. Analogously, we weight the return on each Treasury bond by its size in each investor type's portfolio. That is, the weighted average rate of return on investor type i's portfolio of U.S. Treasury securities from year t to year *t+1*, $\text{RoR}_{i,t+1}$, is calculated as follows:

$$\text{RoR}_{i,t+1} = \sum_{b=1}^{n} \omega_{b,i,t} \text{RoR}_{b,t+1} \tag{1}$$

where i denotes foreign official, foreign private, U.S., or the entire market. $\text{RoR}_{b,t+1}$ is bond b's annual total rate of return (price changes plus interest) from year t to year *t+1*. The weight $\omega_{b,i,t}$ is investor i time t holdings of particular bond $\text{H}_{b,i,t}$ relative to her total holdings:[18]

$$\omega_{b,i,t} = \frac{\text{H}_{b,i,t}}{\sum_{b=1}^{n} \text{H}_{b,i,t}} \tag{2}$$

Results are in Table 1. Using directly observed portfolios, over the period June 2003-June 2019 the composition of private foreign investors' Treasury bond portfolios was such that their returns (3.77 percent per annum) exceeded market returns (3.59 percent). U.S. investors (4.34 percent) also had higher than market returns. And while foreign official investors' returns (3.02 percent) were lower than market returns, the 57 basis point gap is relatively small and statistically insignificant. Combining the foreign official and foreign private portfolios, foreign investors' return of 3.21 percent is only 38 basis points lower than the market, and the difference is not statistically significant.

Robustness checks reported in columns (2) and (3) show that the results are similar if we make adjustments that take into account issues that might arise from the nature of the

[18]Our weights being at time t means that the bond must exist at time t to be included in our returns calculations. This is similar to standard bond index inclusion rules that require the bond to have been issued prior to index rebalancings.

data being reported on a resident basis. For the return calculations in column (2) we shift Belgium's private holdings of Treasuries to the official investors' portfolios. Consistent with our baseline finding that foreign private investors earn higher return than foreign officials, this shift raises the foreign private return just a few basis points, and results are similar if we simply exclude Belgium's private holdings. In column (3) we shift Cayman Islands' holdings from the foreign to the U.S. portfolio, as it is possible that funds in the Cayman Islands are predominantly associated with U.S. operations. This shift lowers U.S. returns a touch and does not change foreign private returns.

3.2 Factors Behind the Average Annual Returns

We next explore factors that underlie the time-weighted returns differentials presented in Table 1. In general, higher mean returns can be obtained either through year-by-year skill/timing in security selection and/or by taking on more risk.

Yield at Different Maturities

We start our investigation by noting that if an investor has bad timing in his purchases of 10-year bonds - for example, by purchasing them when yields are low - then the yield of his 10-year Treasury bonds would be lower than the yields other investors (and the market) earn on their 10-year bonds.

We compute, at each maturity, the yield of bonds in each investor's Treasury portfolio; because we can observe the coupon and price on each and every bond, at a point in time (e.g., June 2012) we can compute each investor's yield on, say, bonds with 10-year original maturity, 5-year original maturity, etc. For comparison, we also compute the market's yield; that is, the average yield of all outstanding 10-year Treasury bonds, 5-year bonds, etc. We present the yield-to-maturity (YTM), which is a function of the bond's price, coupon, and maturity date, of each groups' portfolio of Treasury bonds of 3-, 5-, 7-, and 10-year original

maturity in Figure 7 and 20-30-year maturities in Figure 8.

Focusing first on Figure 7, deviations from market YTM are very small for short maturities and tend to increase with maturity but remain pretty small through 10 years. Specifically, for 3-year bonds, YTMs are nearly identical (usually within 5bps of each other and the market) except in 2016 when the Fed's 3-year bonds had yields 30bps higher than the market. Deviations get larger on average as maturity increases, but remain close to market for 5-year bonds (almost always within 10-15bps), 7-year (within 20bps), and 10-year (still usually within 20bps). Only at 20-30-year maturities (Figure 9) does the spread widen much (to 50bps); even so, there are not many bonds (less than 20 percent) in this bucket.

Spreads are pretty small, at least through 10 years, but are there noticeable differences across investor types? For 3-year bonds, differences are miniscule except that the Fed in 2010 and 2013 was 10bps below market and in 2016 was 30bps above market. Deviations from market are also very small for 5-year bonds; U.S. investors did best 2007-2017 (but never more than 12bps from market), Foreign Private was next best and Foreign Official was worst (but never more than 12bps below market). For 7-year bonds, U.S. investors were consistently best, with Foreign Private a very close second, and Foreign Official consistently lower. For 10-year bonds, U.S. investors and (more consistently) Foreign Private were usually best, Foreign Official was below market 2009-2014 but otherwise right at market. Turning to the 20-30-year bonds, U.S. investors had the highest yields starting in 2009, often 20bps better than market (and 40bps in 2011), Foreign Official had the lowest, and Foreign Private was pretty much right at market.[19]

Overall, an examination of the YTMs indicates that the yields by maturity bucket in foreigners' Treasury portfolios are similar to other investors'. We find no evidence that foreigners purchased bonds of a particular maturity at the wrong time.

[19] 30-year bonds were not issued by the U.S. Treasury between Feb. 2002 and Feb. 2006. In 2011, the year of the largest difference in YTMs, long bonds were only 4 percent of foreign officials' Treasury portfolios.

Duration

We next turn to the riskiness of the portfolios. In particular, we focus on duration (Figure 9). Over the period 2003-2019, market duration was between 5 and 6.5 years (with an average of 5.78). Among investor types, U.S. investors had the longest duration for most of the period and in general stayed between 7 and 8.5 years (average 7.33). The duration of foreign private investors (average 6.60) fluctuated between 6 and 7, but since 2015 has trended up. Foreign officials had by far the shortest duration (between 3.5 and 4.5 years, average 4.09). The Fed's duration extended in the 2012-2014 period (following Operation Twist) and averages 6.05 years.

The ordering of durations is very similar to the time-weighted returns presented in Table 1. U.S. investors had both the highest mean return and the longest duration Treasury portfolio. Private foreign investors and the Fed are next in terms of duration and mean returns. And foreign officials have the lowest duration portfolio and the lowest mean returns. That is, some of the returns differentials across investor types seem to be attributable to different levels of risk (as measured by duration).

Sharpe ratios (Table 2) confirm this. All investor types' Sharpe ratios are similar, indicating that the higher returns earned by U.S. investors came with higher risk. In fact, U.S. investors' Sharpe ratio is the lowest at 0.48, below the market (0.51) and private foreign (0.49). Surprisingly, and abstracting from the Fed, the best performance comes from the foreign official portfolios; their low mean return came with very low volatility and so produced the highest Sharpe ratio of 0.54.

Figure 10 depicts this another way. U.S. private investors have the most volatile returns (top graph) and are otherwise very similar to foreign private (bottom graph). Indeed, correlations of quarterly flows (not shown) indicate that U.S. private flows are positively correlated with foreign private flows and negatively correlated with foreign official and Fed

flows.

Summary of Time-Weighted Returns Differentials

Overall, careful examination of the composition of Treasury portfolios indicates that time-weighted average annual returns differentials are pretty small, private foreign investors actually beat the market on average, there is no evidence of meaningful skill/timing differentials when looking at bonds with similar characteristics (i.e., within a particular maturity bucket), and most importantly any returns differential seems to be a direct function of risk. To get the highest return, U.S. investors hold the longest duration portfolio, and that portfolio had by far the most volatility. U.S. investors had the lowest Sharpe ratio, while the short-duration foreign official portfolio had a high Sharpe ratio.[20]

4 Dollar-Weighted Returns

Time-weighted returns indicate little difference between investor types. But time-weighted returns are a function of the composition of a portfolio, not the evolution of its size, so do not capture the timing and amount of purchases. In contrast, dollar-weighted returns incorporate the effects of the timing of purchases, allowing us to answer the following question: Through time did an investor type's purchases lead to higher returns?

In this section we compute the internal rate of returns (IRR) using a technique based on Dichev and Yu (2011), which computed returns earned by the average hedge fund investor using only data on funds' assets under management (AUM) and fund-reported returns series (which combined allow the calculation of flows). In Dichev and Yu (2011), the hedge fund investment is viewed as a capital project, where the initial investment and intermediate

[20] An interesting question that we cannot address with our annual data is if foreign officials' returns are boosted by selling during crises, when Treasury prices are high. The case against this is implied in Vissing-Jorgensen (2021), which notes, using quarterly BEA data, that foreign officials' behavior varies across crises, as they purchased Treasuries in 2008Q4 and sold in 2020Q1.

capital contributions are capital inflows, and capital distributions and ending AUM are capital outflows. The intermediate capital contributions are computed as:

$$\text{Capital Inflows}_t = \text{AUM}_t - \text{AUM}_{t-1}(1 + \text{r}_t) \tag{3}$$

where r_t is funds' reported net-of-fees return. Solving for the IRR of this time-ordered schedule of capital flows yields the dollar-weighted return on this investment. Specifically, the dollar-weighted return is defined as the rate of return that equates the discounted ending asset value to the sum of the initial AUM and the present value of the capital flows realized over the life of the fund.

Porting the Dichev and Yu (2011) methodology to our setting requires four components:

- initial investment, given by the market value of foreigners' initial holdings,
- intermediate contributions or capital inflows, given by net purchases each period,
- capital distributions, which are the income stream of coupon payments, computed by applying each bond's coupon yield to its face value, and
- terminal payout, given by the market value of bond holdings at the end of the sample.

For example, our security-level data on each bond's market value, face value, and coupon yield, as well as our security-level-based flows, allow us to compute foreigners' IRR for a sample period of mid-2003 through mid-2019 using the following components:

- the initial investment is the sum of the market value of their holdings of each Treasury bond at the end of June 2003 (assumed to all be purchased at that time),
- intermediate contributions are our computed bond-by-bond net purchases from mid-2003 through mid-2019,

- intermediate distributions are coupon payments each period from mid-2004 through mid-2019, computed at the security-level from the bond's coupon yield and face value, and
- the final payout is equal to the sum of the market value of their holdings of each Treasury bond as of end-2019.

It is important to note that the Dichev and Yu (2011) technique requires that the current value of holdings A_t equals last period's holdings revalued plus any net purchases during the period:

$$\mathrm{A}_t = \mathrm{A}_{t-1}(1 + \mathrm{r}_t) + \text{Net Purchases}_t \tag{4}$$

If there is a disconnect between positions and flows, the IRR will be mismeasured. For example, consider including another term, Other Adjustments or OA, on the right side:

$$\mathrm{A}_t = \mathrm{A}_{t-1}(1 + \mathrm{r}_t) + \text{Net Purchases}_t + \text{Other Adjustments}_t \tag{5}$$

If OA > 0, flows are undercounted (relative to positions) and IRRs will be overstated. If OA < 0, flows are overcounted and IRRs will be understated. While most datasets on international investment have non-zero OA (because flows and positions tend to be collected in different systems), in our security-level data OA is zero.[21] Moreover, we can precisely measure coupon payments by summing, for each bond, the coupon yield times face value.

[21] To our knowledge, for higher frequency publicly available data on U.S. international portfolios, only the BTBJ dataset has OA = 0. BEA data and, hence, FOF data include non-zero Other Adjustments. That is, BTBJ data satisfy equation (4), while FOF (which relies on BEA data) has a discrepancy between the left and right sides of that equation. The discrepancy, the so-called Other Adjustments, means that FOF data (especially pre-2003) shouldn't be used to create IRRs. Indeed, the Curcuru, Dvorak, and Warnock (2008) and Curcuru, Thomas, and Warnock (2013) view of the early literature on exorbitant U.S. returns differentials is that results hinged on an OA that was at times substantial. Finally, we note that even though OA is zero in BTBJ, data quality is better starting in 2000, when the surveys that provide the important fixed points became more frequent.

Table 3 presents IRRs for foreigners (separating out private and official foreign investors), U.S. investors, and the Fed (for completeness) over the period from mid-2003 to mid-2019. U.S. investors' holdings are calculated as the residual: total outstanding marketable Treasury bonds less foreign and Fed holdings. We also show a market IRR computed in the same manner as the other IRRs, as well as for the float (market excluding the Fed). The most accurate estimates are in column (1), which is based entirely on security-level data. As shown in column (1), the Fed's returns are the highest (3.93 percent), as the bulk of its purchases were in 2011-2013 (Figure 6), just prior to strong Treasury bond returns (Figure 10).[22] Foreign officials had the next highest dollar-weighted returns (2.58 percent), as the bulk of their purchases were early in the sample when returns were high. Private foreign investors (2.36 percent) had higher dollar-weighted returns than U.S. investors (2.23 percent). Comparing investors' returns to the float (i.e., market minus Fed) return of 2.35 percent, foreign investors had higher returns (relative to float, foreign official was 23 bps above, foreign private was 1 bps above) and U.S. investors had lower returns (12 bps below float).

The estimates in column (1) are precise, as every component is built using security-level data. Such data, especially on foreigners' portfolios, are not publicly available, so in columns (2) - (4) we incrementally bring in publicly available data. Column (2) uses the face value of holdings - again, something not generally available - but applies an off-the-shelf market coupon yield (the BoAML coupon) to calculate coupon payments. Doing so materially changes returns - the Fed's return falls and all other returns increase - but not the ordering. In column (3) coupon payments are computed from market value series, which is not the correct way to compute them but uses publicly available data; relative to column (2), doing so slightly increases returns for all but U.S. investors and, again, does not change the ordering.[23] In column (4) we show the effect of going from annual to quarterly

[22]The Fed remits any excess profits on its security holdings to the U.S. Treasury.

[23]For the market's market value, we subtract FOF Table L.210 line 58 (the discrepancy) from line 4 (other Treasury notes, bonds and TIPS).

observations by using quarterly BTBJ data. Moving to quarterly data has near-zero effect on the estimates. Overall, the biggest changes in moving from annual security-level data and best methodologies (column 1) to using index coupon yields for all, applying those yields to market value, and using quarterly data appear to come from using an off-the-shelf coupon yield rather than security-specific information on coupons.

Finally, while we are less comfortable calculating IRRs for the period that pre-dates annual surveys (i.e., prior to mid-2003), in Figure 11 we show foreign IRR minus market IRR, calculated using BTBJ data (as in Table 3, column (4)), for 20-year holding periods starting end-1979. Foreigners' IRR was higher than the market IRR for 20-year holding periods starting in the early 1980s; for holding periods starting between 1985 and 1995 were sometimes higher, sometimes lower; and for 20-year holding periods starting since 1996 have been roughly equal to the market IRR.

In sum, IRRs computed from security-level data on positions, flows, and coupon payments indicate that both private and official foreigners outperform U.S. investors. IRRs computed using less precise data on coupon payments - that is, by assuming coupon yields are applied to the market value of the bond and/or applying a general coupon yield to every bond - provide different magnitudes but do not change the ordering across investor types. And using data not designed to compute IRRs and extending back further in time (when the BTBJ data have fewer fixed points to calibrate to) indicates that there are a few 20-year holding periods in which foreigners had lower than market returns. But overall, the evidence is not supportive of a view that foreigners have poor timing.

5 How Foreigners Alter Their Treasury Portfolios

Data limitations have impeded the ability to gauge how foreigners alter their Treasury portfolios. We can address this in two ways. First, similar to the analysis in Section 3 we can

use the annual security-level survey data to focus on portfolio composition - specifically, how foreigners change the duration of their Treasury portfolios when spreads change. Second, analogous to the analysis in Section 4, we can examine the magnitude of purchases: the evolution of flows in response to changes in spreads. On the latter, we recognize that the annual SHL data, while detailed and the best quality, have limitations. For example, if foreigners have sizeable net purchases, then contemporaneous annual regressions will be hindered by price pressure: Is it that foreign officials buy Treasuries when they are expensive or that foreigners' purchases make Treasuries expensive? Lagging yields could help, but a full year lag is a bit extreme. All this suggests turning to flows from the higher frequency (monthly) aggregate flows of BTBJ, which are better suited to capture leads and lags in the relationship between flows and yields.

In both analyses in this subsection we make use of data on CIP deviations from Du and Schreger (2016) and Du, Im, and Schreger (2018). Briefly, we will use 10yr SynDiff, country j's synthetic yield difference - synthetic dollar sovereign yield minus U.S. Treasury yield - where the synthetic dollar sovereign yield (10yrSynSov) is constructed using Du, Im and Schreger's data on the forward premium. Note that the synthetic yield difference is also called the CIP deviation.

5.1 Duration

We can use the security-level data to gauge how the composition of foreigners' U.S. Treasury bond portfolios - specifically, how the duration of those portfolios - changes with changes in the sovereign rate, the synthetic (i.e., CIP-adjusted) sovereign rate and the Treasury rate. The panel regressions we run are as follows:

$$\text{Dur}_{j,t} = \alpha + \beta \Delta 10\text{yr SynDiff}_{j,t} + c_j + \eta_t + \epsilon_{j,t} \tag{6}$$

$$\text{Dur}_{j,t} = \alpha + \beta \Delta \text{Y}_{j,t} + \Delta \text{Y}_t^{\text{US 10yr}} + c_j + \epsilon_{j,t} \tag{7}$$

The dependent variable ($\text{Dur}_{j,t}$) is the weighted average duration of country j's portfolio of U.S. Treasury securities in year t; that is, it is built from the security-level holdings and security characteristics, with duration being aggregated to the country-year using bond size-based weights. In equation (6) the explanatory variable, 10yr SynDiff, is country j's synthetic yield difference (synthetic sovereign yield minus U.S. Treasury yield). In equation (7), in addition to the 10-year U.S. Treasury yield (US 10yr) we also include the components of the synthetic yield difference: variable $\text{Y}_{j,t}$ is either country j's sovereign local currency 10-year bond yield (Sov10y) or country j's synthetic dollar sovereign yield (10yr SynSov). All explanatory variables are in changes. In Table 4 we report the results separately for foreign private and foreign official investors. Since the focus is on sovereign rates and the Treasury basis, the sample excludes Belgium, Ireland, and Luxembourg, because these countries house custodians that primarily serve investors from other countries.[24] All specifications include country fixed effects (c_j); time fixed effects (η_t), are included in columns 1 and 5 (corresponding to equation (6)); and standard errors are clustered on country.

Results indicate that private foreign investors extend the duration of their Treasury portfolios when their country's synthetic yield difference (the CIP deviation or negative of the Treasury basis) becomes more negative (columns 1 and 2). Unpacking the components of the synthetic difference, private foreigners appear to be reacting to changes in their countries' synthetic dollar yield (column 3), not to changes in U.S. Treasury yields or their sovereign local currency rates (column 4). Foreign officials (columns 5-8) seem different. The only significant coefficient, although only marginally so, in the foreign officials regressions is on

[24]Our sample also excludes the Caribbean banking centers because these countries do not have significant sovereign debt outstanding and therefore lack reliable data on sovereign rates. Moreover, their investments are predominantly held on behalf of a diverse group of non-residents, for whom the interest rate to use is ambiguous.

changes in their own sovereign yield: When the sovereign yield increases, foreign officials extend the duration of their Treasury portfolios (although as a group their portfolios have the lowest duration of any investor group).

We note that included in foreign private are insurance companies and pension funds (ICPF) who might match the duration of their liabilities. To check if these investors influence our results, we control for the size of each country's ICPF sector (measured as the size of the sector's assets relative to total domestic assets) by using a dummy variable of high versus low based on the sample median. This ICPF size dummy, constant over time within a country, does not appear to be a significant determinant in foreign investors' behavior (Table 5).

Overall, results in Tables 4 and 5 indicate that foreign private investors lengthen the duration of their Treasury portfolios when the Treasury basis increases (i.e., CIP deviation decreases), but foreign officials do not. The different results for private and official foreigners are consistent with evidence in Krishnamurthy and Vissing-Jorgensen (2007) that foreign officials' demand is less elastic than other investors', but inconsistent with Krishnamurthy and Lustig (2019) and Jiang et al. (2021) findings that foreigners have inelastic demand.

5.2 Foreign Flows and Yields

Does the volume of foreigners' flows into Treasuries react to changes in Treasury yields? Answering this requires data at a higher frequency than annual, so we turn to aggregate (i.e., not security-level) monthly BTBJ data of Bertaut and Tryon (2007) and Bertaut and Judson (2014). We run separate regressions for each foreign investor type i (total foreign, foreign official, and foreign private) flows and for each lag k of the CIP deviation as follows:

$$\text{Flow}_t/\text{Position}_{t-1} = \alpha + \beta(\text{CIP}_t - \text{CIP}_{t-k}) + \epsilon_t \tag{8}$$

$$\text{Flow}_t/\text{Position}_{t-1} = \alpha + \beta \text{CIP}_{t-k} + \epsilon_t \tag{9}$$

In Figure 12 we plot the β coefficients from each time series regression we run for each lag k. Each plot in Figure 12 shows, from 13 time series regressions of flows regressed on lagged 10-year G10 CIP deviation (CIP) and a constant, the β coefficients of CIP deviation lags from 0 to 12 months. Lags are cumulative changes (left column, corresponding to eq. (8)) or simple levels (right column, corresponding to eq. (9)). Flows, scaled by lagged positions, are total foreign (top row), private foreign (middle), or foreign official (bottom). The sample period is January 1999 through December 2019.[25] CIP deviation is computed as a weighted average of G10 CIP deviations, with the weights coming from each country's holdings of Treasuries. Plotted are coefficients (the dot in each graph), two standard deviation error bands (the vertical lines), and the statistical significance at the 1, 5 or 10 percent level (the stars).

The evidence indicates that foreigners purchase Treasuries after the CIP deviation is low or falling, that is when the synthetic dollar yield is low (or has fallen) relative to the Treasury yield. For private foreigners (middle row), this relationship holds at 0-4-month lags of levels (right column) and cumulative lags of changes starting at a lag of 6 months (left column). Total foreign results (top row) are similar but less precisely estimated; the top row graphs are very similar to those in the middle row. In contrast to total foreign and private foreign, foreign officials (bottom row) do not seem to adjust their net purchases based on the levels of or changes in CIP deviations.

Overall, the evidence in Figure 12 indicates that private foreigners' purchases of Treasuries are higher following low or falling CIP deviations and foreign officials can be characterized as having inelastic demand. This is consistent with the finding in Krishnamurthy and

[25]The CIP deviation data, available at https://sites.google.com/view/jschreger/CIP, begin in 1997, but data for the euro area do not start until the euro's inception, so our analysis will start in January 1999.

Vissing-Jorgensen (2007) that private foreign investors are more price elastic than official investors and with the model of Greenwood et al. (2020), but inconsistent with the Krishnamurthy and Lustig (2019) and Jiang et al. (2021) findings that foreigners have inelastic demand.

6 Conclusion

Foreigners' U.S. Treasury portfolios figure prominently in theories but typically their behavior - the nature and evolution of foreigners' Treasury portfolios - has been inferred from aggregate statistics that are not always internally consistent. We directly observe foreigners' Treasury portfolio at the security level and find results that strikingly differ from the existing literature. Foreigners do not earn a low return on their Treasury portfolios, have higher Sharpe ratios than U.S. investors, do not have poor timing, and private foreign investors appear to be price sensitive.

Our results have implications for the convenience yield literature. While that literature has become well entrenched since Krishnamurthy and Vissing-Jorgensen (2007, 2012), it is still evolving. A straightforward takeaway is that the convenience yield literature should not rely on foreigners being different. Rather than foreigners having spectacularly poor timing (Krishnamurthy and Lustig (2019)) and a much larger convenience yield than U.S. investors because they buy Treasuries when Treasuries are expensive (Jiang et al. (2021)), we find, using the best available data, that foreigners' Treasury portfolios earn returns that are comparable to other investors, and that private foreigners respond to changes in spreads, which is not consistent with notions of inelastic demand.[26] Our results are consistent with

[26]The portion of the convenience yield literature that relies on foreigners being different uses, from paper to paper, various measures of foreigners' poor returns on U.S. Treasuries. Jiang et al. (2021) use foreigners' returns on their own bonds minus their returns on U.S. Treasuries and put the gap at 277 bps. It is unclear how the first component is calculated, but a comparison of returns from ICE BofAML U.S. Treasury index (code: G0Q0) to a hedged global exUS index (ICE BofAML Global Government exUS index: N0G1) from 1986q1 (when the global exUS index starts) to 2019q2 puts the gap at only 40 bps. Krishnamurthy and

all investors placing the same convenience yield on Treasuries, suggesting that the literature should focus on notions (and calculations) of convenience yields that do not rely on foreigners being different. More general notions of a convenience yield, such as in van Binsbergen, Diamond, and Grotteria (2022), tend to produce much smaller convenience yields of around 40 basis points, estimates not inconsistent with ours. Other notions of convenience yields that do not rely on foreigners being different include Piazzesi, Rogers, and Schneider (2021) and Krishnamurthy and Vissing-Jorgensen (2012). Similarly, Du, Im, and Schreger (2018) CIP deviations apply to all investors. There may well be a convenience yield, but our evidence questions whether it applies differentially.

Our paper also has important implications for anyone using data on international flows and positions. There are multiple data sources, some that we show should not be used (and, in fact, will soon be discontinued), others that are more accurate but can still be confusing (see, for example, discussions about BTBJ data in Meng and van Wincoop (2020) and Chari, Dilts Stedman, and Lundblad (2021)). Our advice for anyone using data on international flows and positions is straightforward: Check data quality, if possible, and know what the series represent.

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Lustig (2019) compare foreigners' IRR to a Treasury index return, but IRRs and index returns are not directly comparable; for example, the Treasury index return for 2003q3-2019q2 is 85 bps higher than our security-level market IRR.

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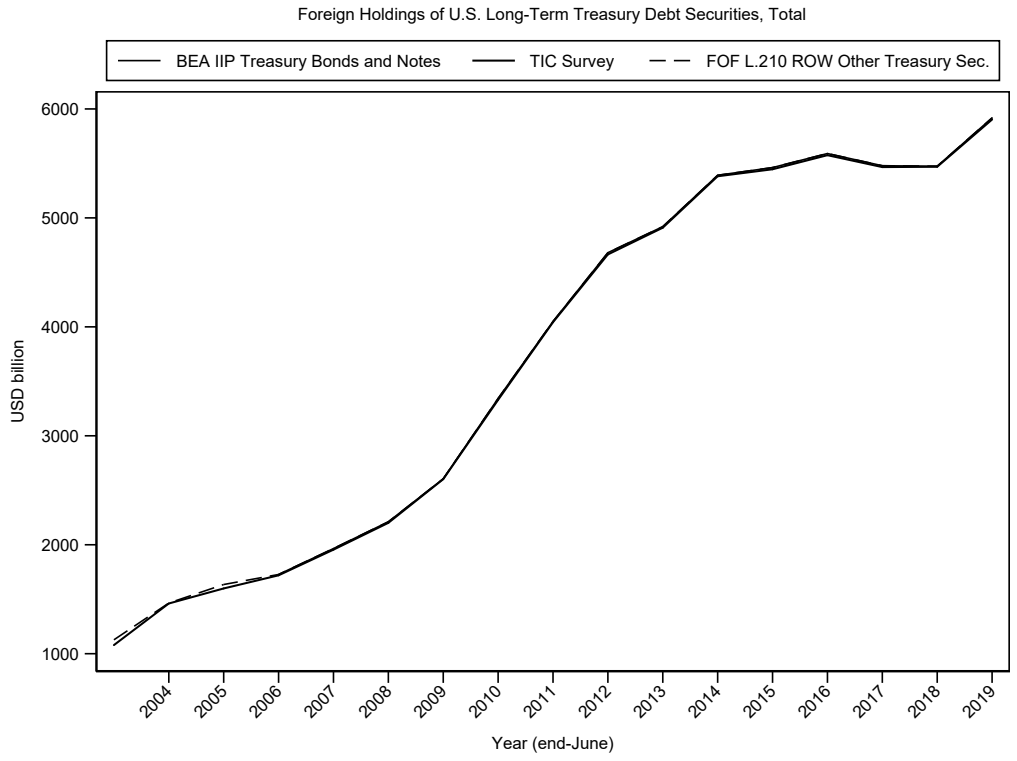
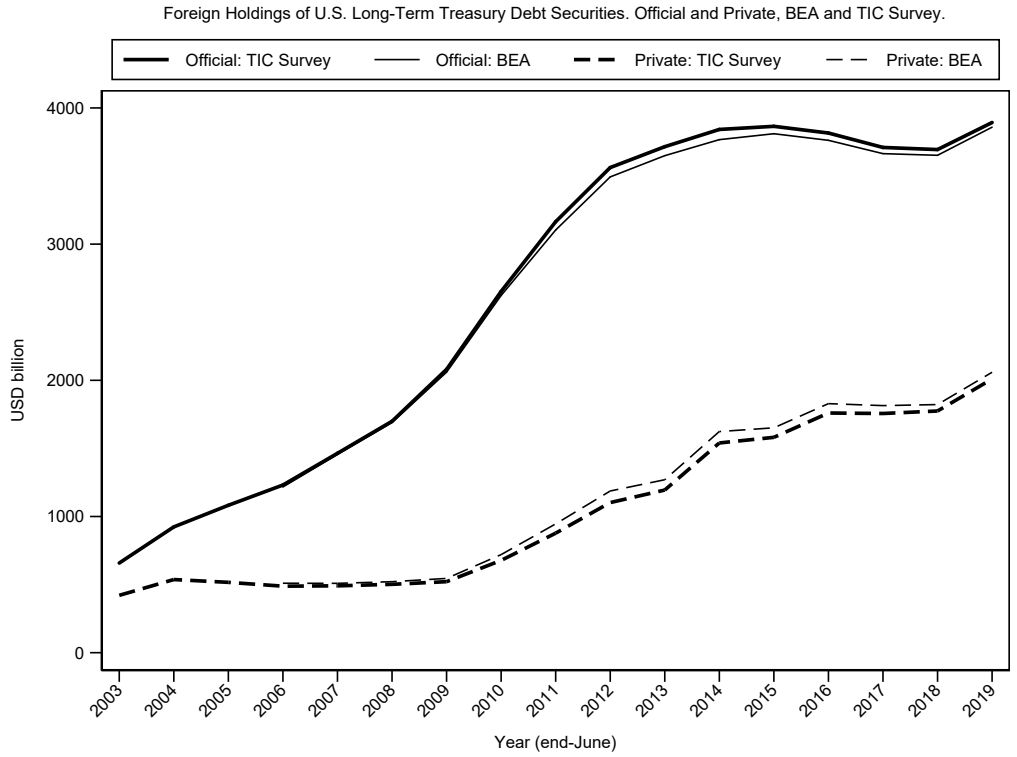
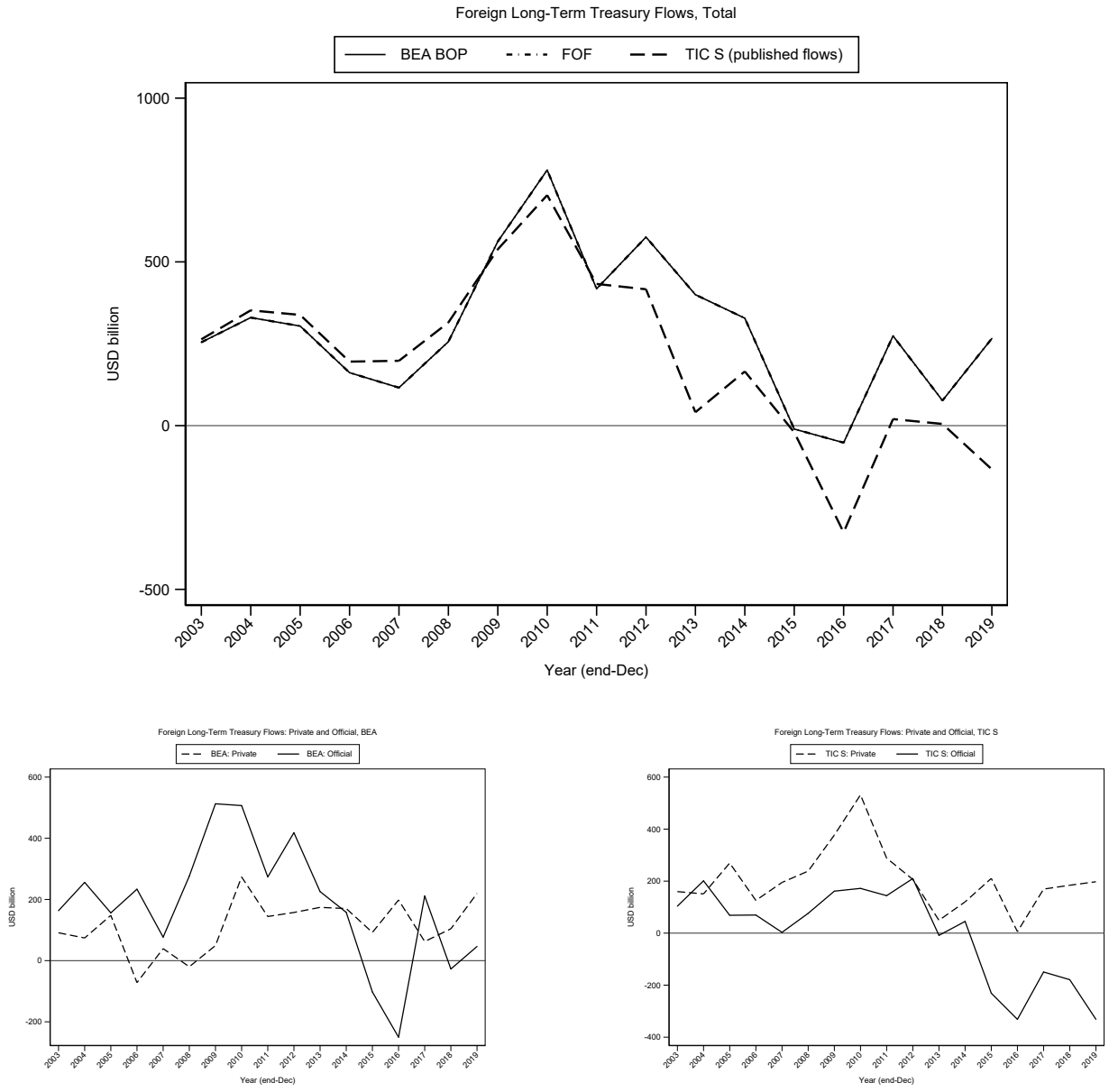
Figure 1: Foreign Holdings of U.S. Long-Term Treasury Securities





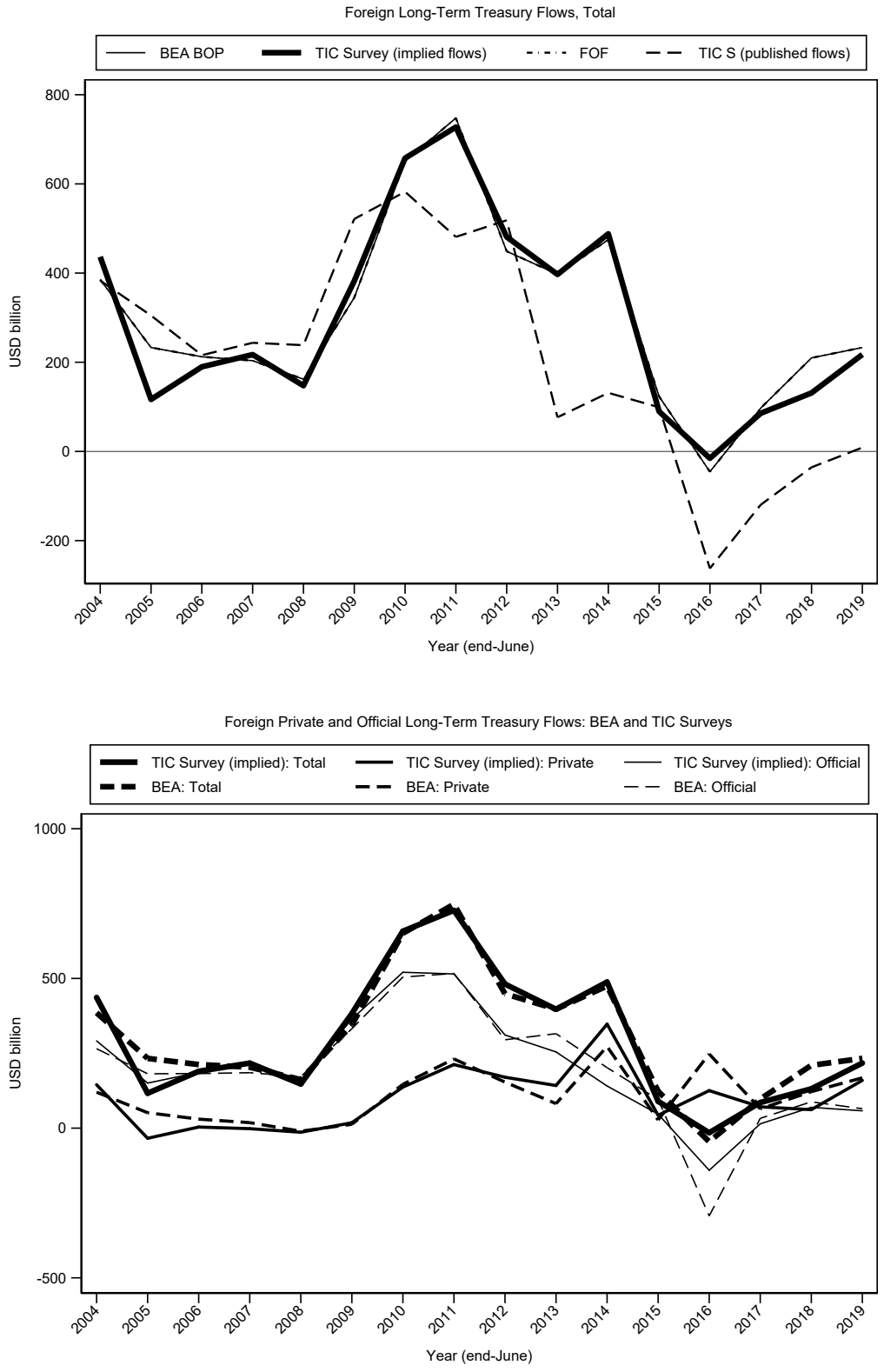
The figure shows, using data from three sources - BEA, TIC surveys, and FOF - the evolution of foreigners' holdings of U.S. Treasury bonds and notes (annual, in billions of U.S. dollars). The lower graph shows foreign private and foreign official holdings (a split that is no longer available in FOF data).

Figure 2: Foreigners' Net Purchases of U.S. Long-Term Treasury Securities



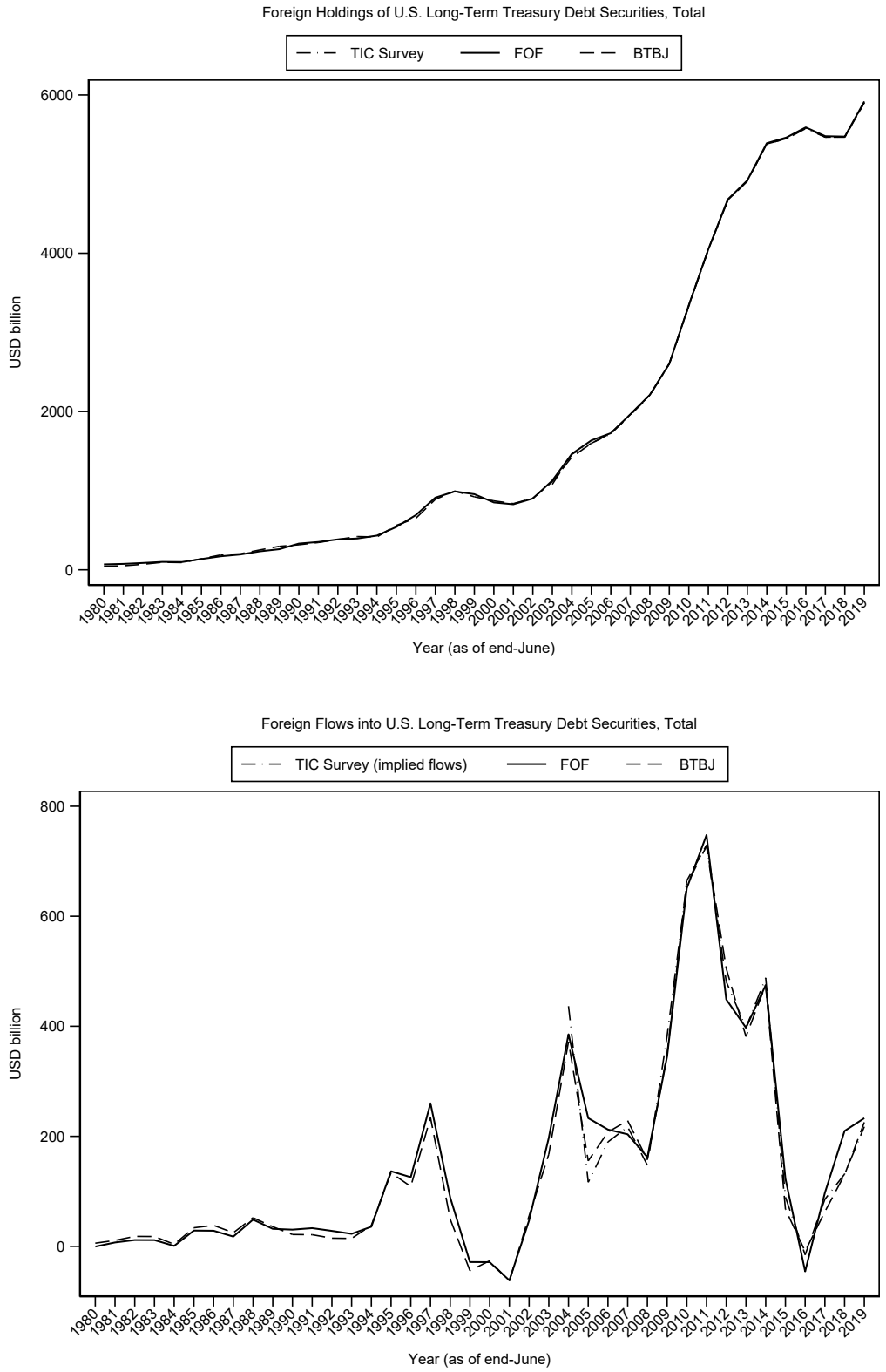
The figure shows, using data from three sources - BEA, TIC S, and FOF - the evolution of foreign flows into U.S. Treasury bonds and notes (annual, in billions of U.S. dollars). The lower graphs show foreign private and foreign official flows (a split that is no longer available in FOF data).

Figure 3: Foreigners' Net Purchases of U.S. Long-Term Treasury Securities



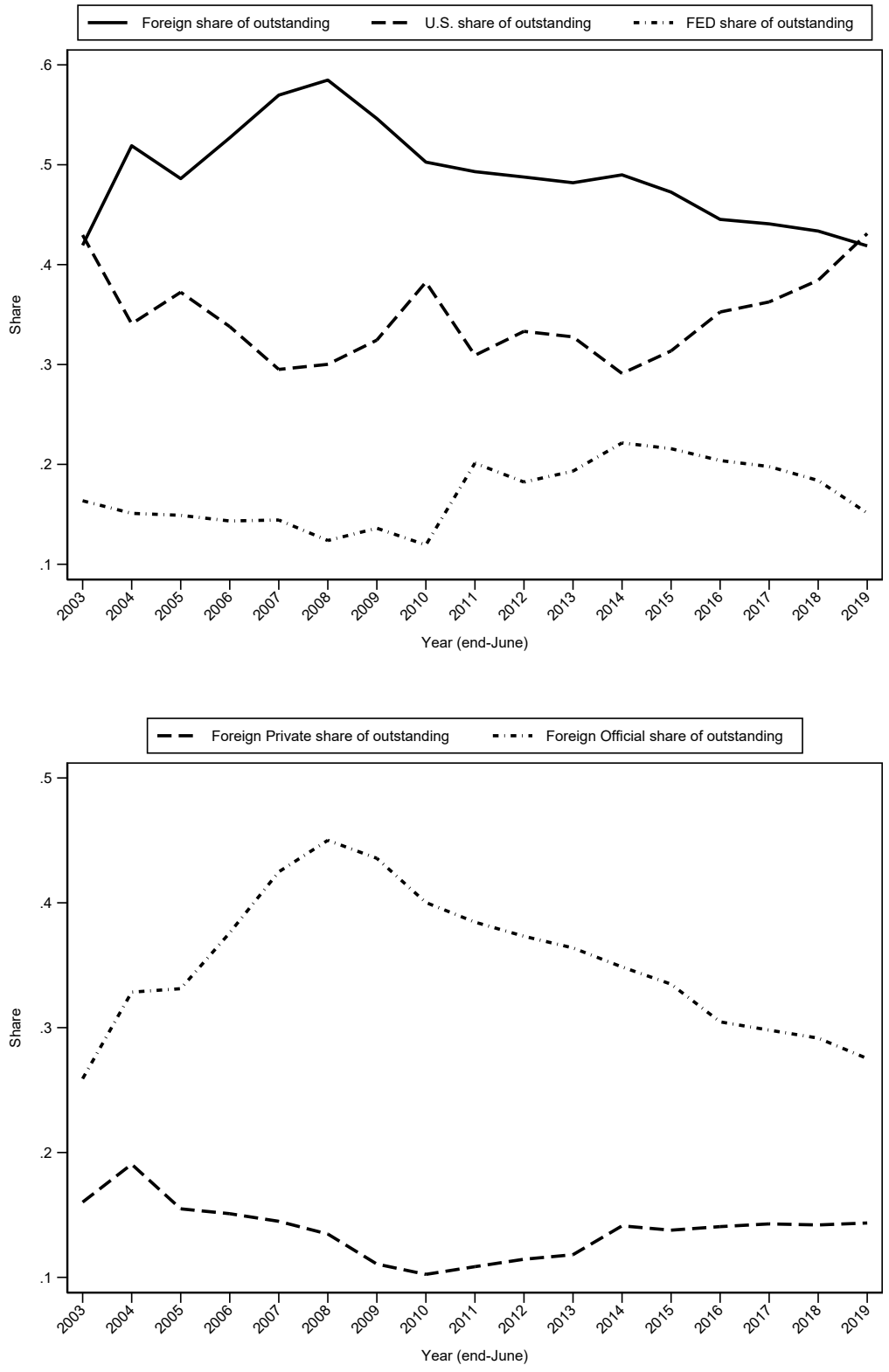
The figure shows, using data from four sources - BEA, TIC annual surveys, TIC S, and FOF - the evolution of foreign flows into U.S. Treasury bonds and notes (annual end-June to end-June, in billions of U.S. dollars). The lower graph shows foreign private and foreign official flows (a split that is no longer available in FOF data).

Figure 4: Foreigners' Holdings and Net Purchases of U.S. Long-Term Treasury Securities



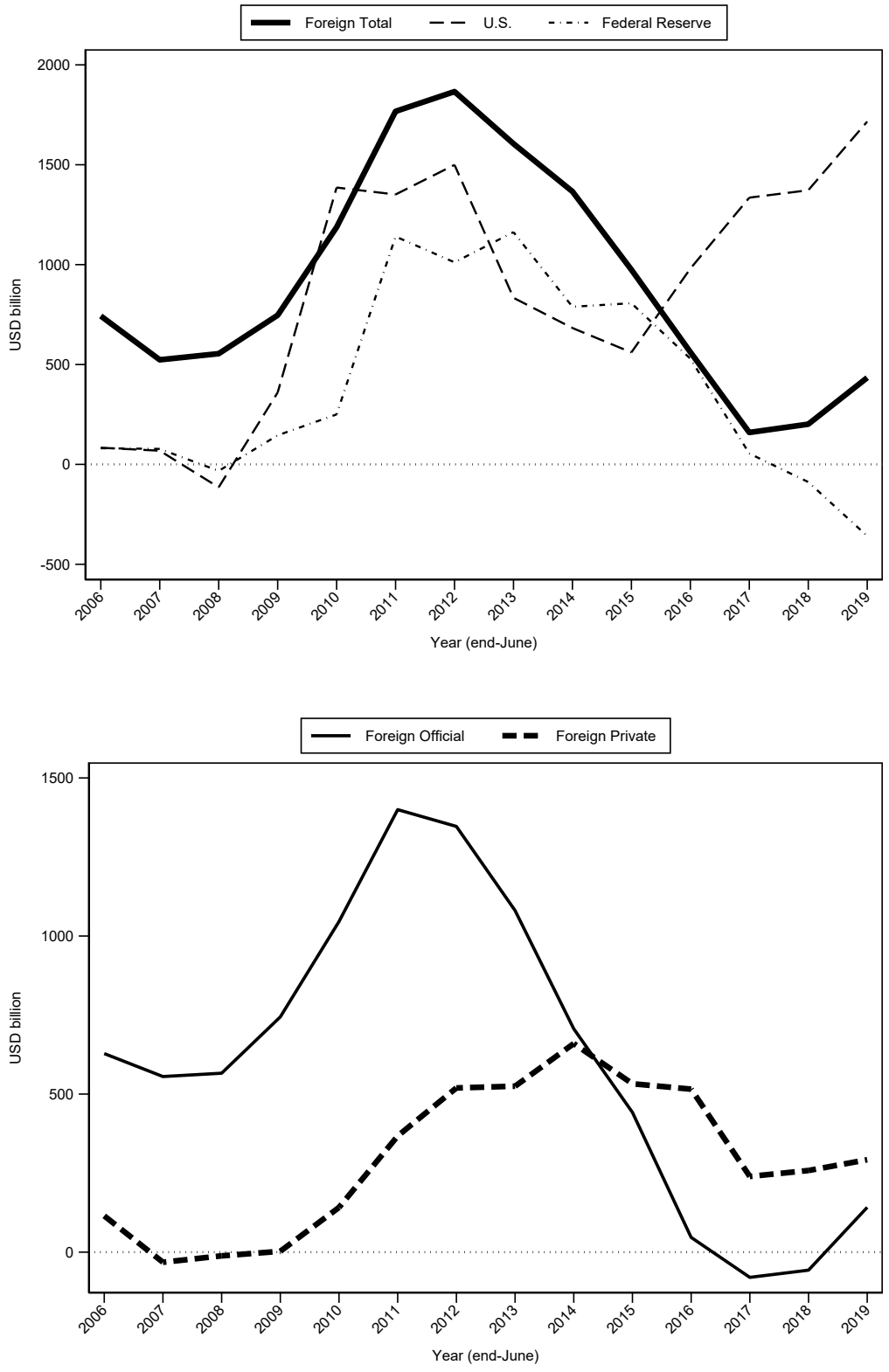
The figure shows, using data from three sources - FOF, TIC surveys, and BTBJ - the evolution of foreign holdings of and flows into U.S. Treasury bonds and notes (annual end-June to end-June, in billions of U.S. dollars).

Figure 5: U.S. Treasury Holdings by Investor Type



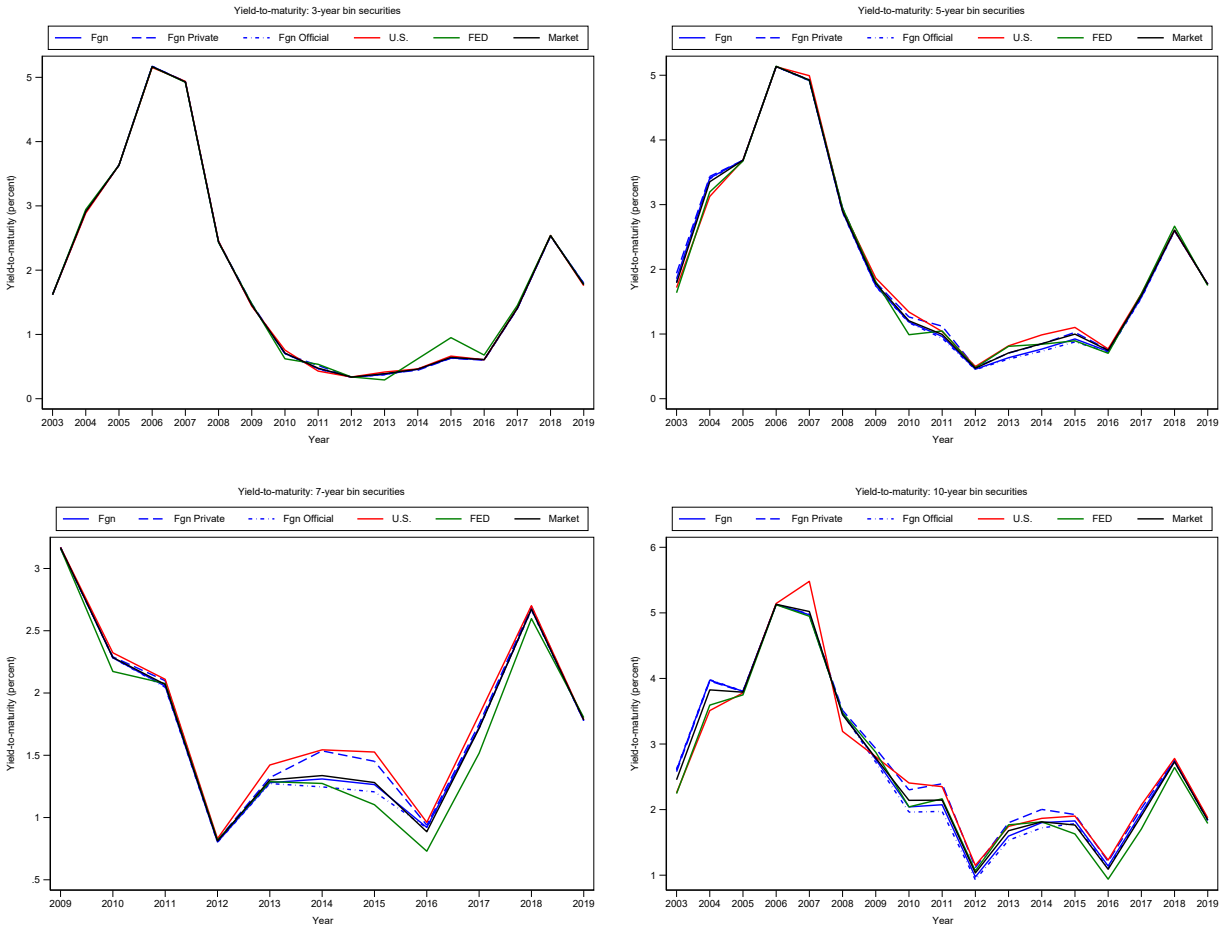
The figure shows the share of long-term Treasuries held by U.S. investors, the Fed, and foreigners (split between foreign private and foreign official in the bottom graph).

Figure 6: U.S. Treasury Flows by Investor Type: 3-year rolling sum



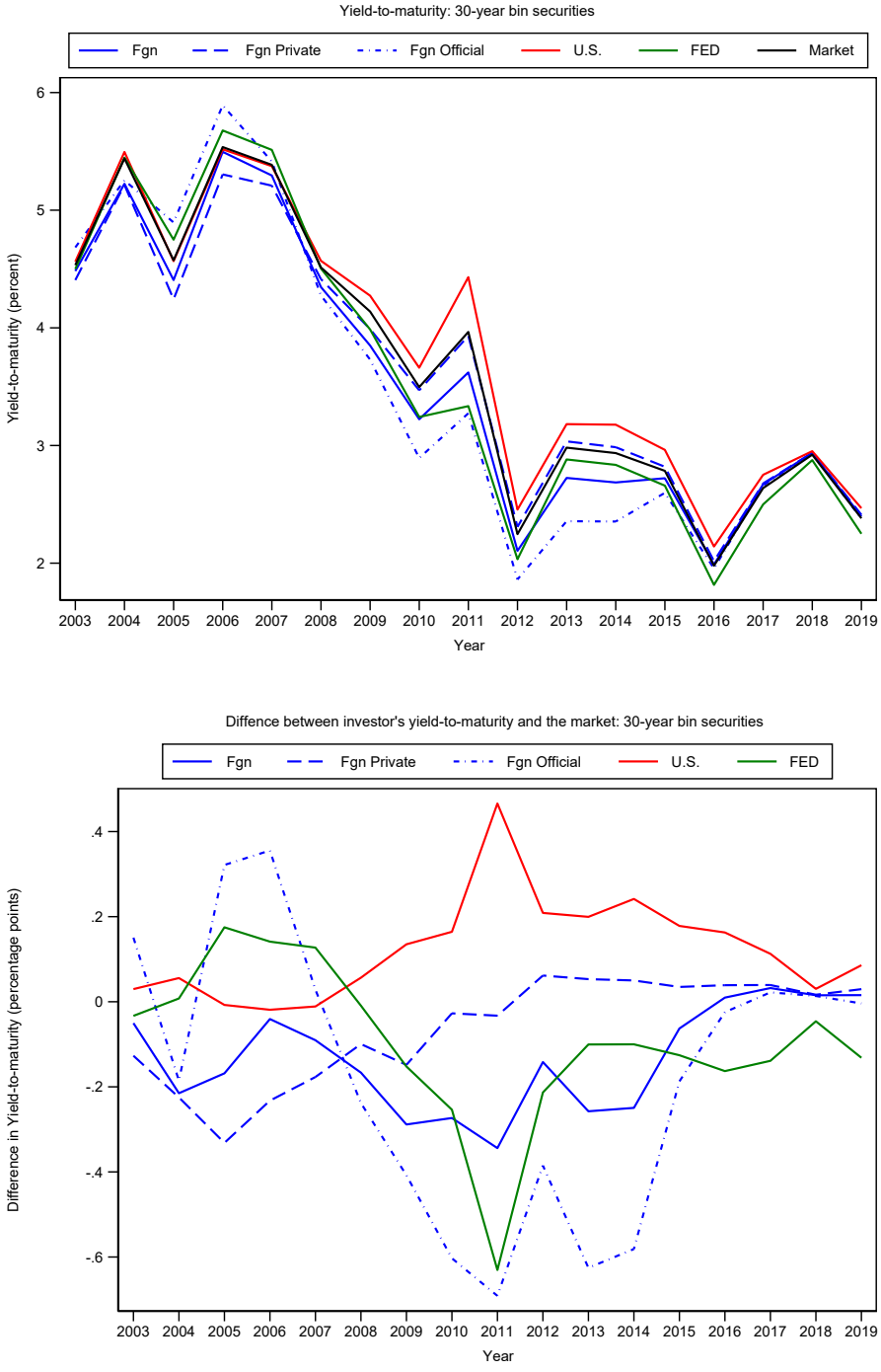
The figure shows net purchases (3-year rolling sum using annual end-June to end-June data, in billions of U.S. dollars) of long-term Treasuries by U.S. investors, the Fed, and foreigners (total, foreign private and foreign official).

Figure 7: Yield-to-maturity of Treasury holdings per investor type by original maturity



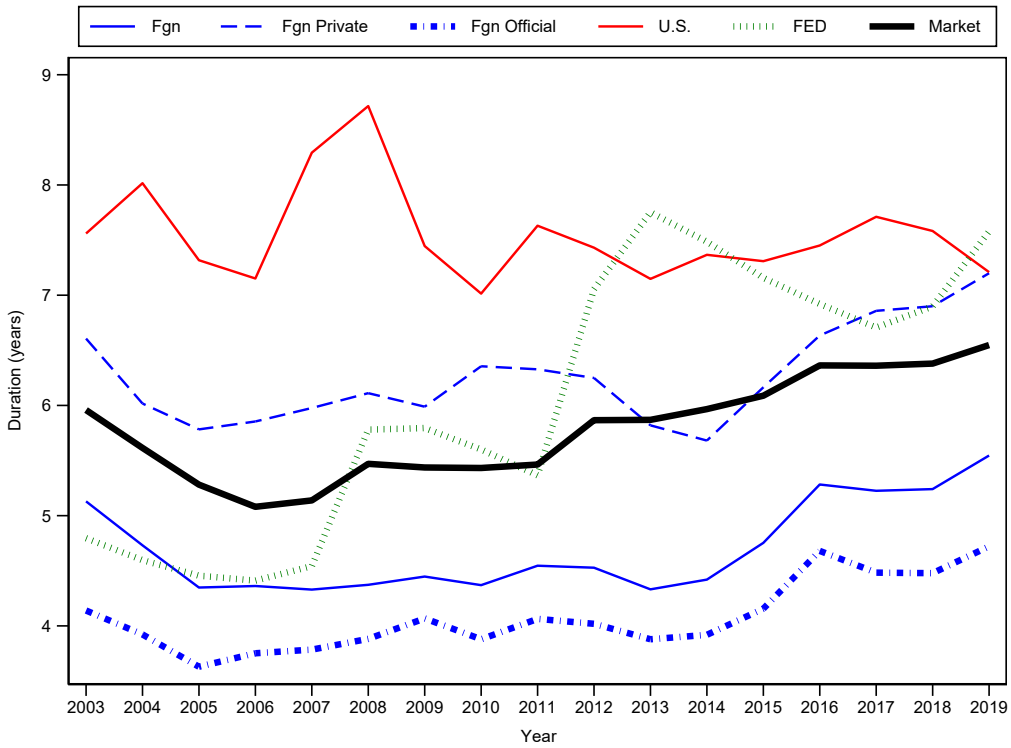
The figure plots weighted averages of yield-to-maturity by investor type and by original maturity (3, 5, 7 and 10 years). Market refers to all outstanding marketable Treasuries as reported by Treasury Direct. Sample excludes floating rate notes (FRN), Treasury inflation protected securities (TIPS), and securities maturing within one year.

Figure 8: Yield-to-maturity of Treasury holdings per investor type: 20- and 30-year maturity



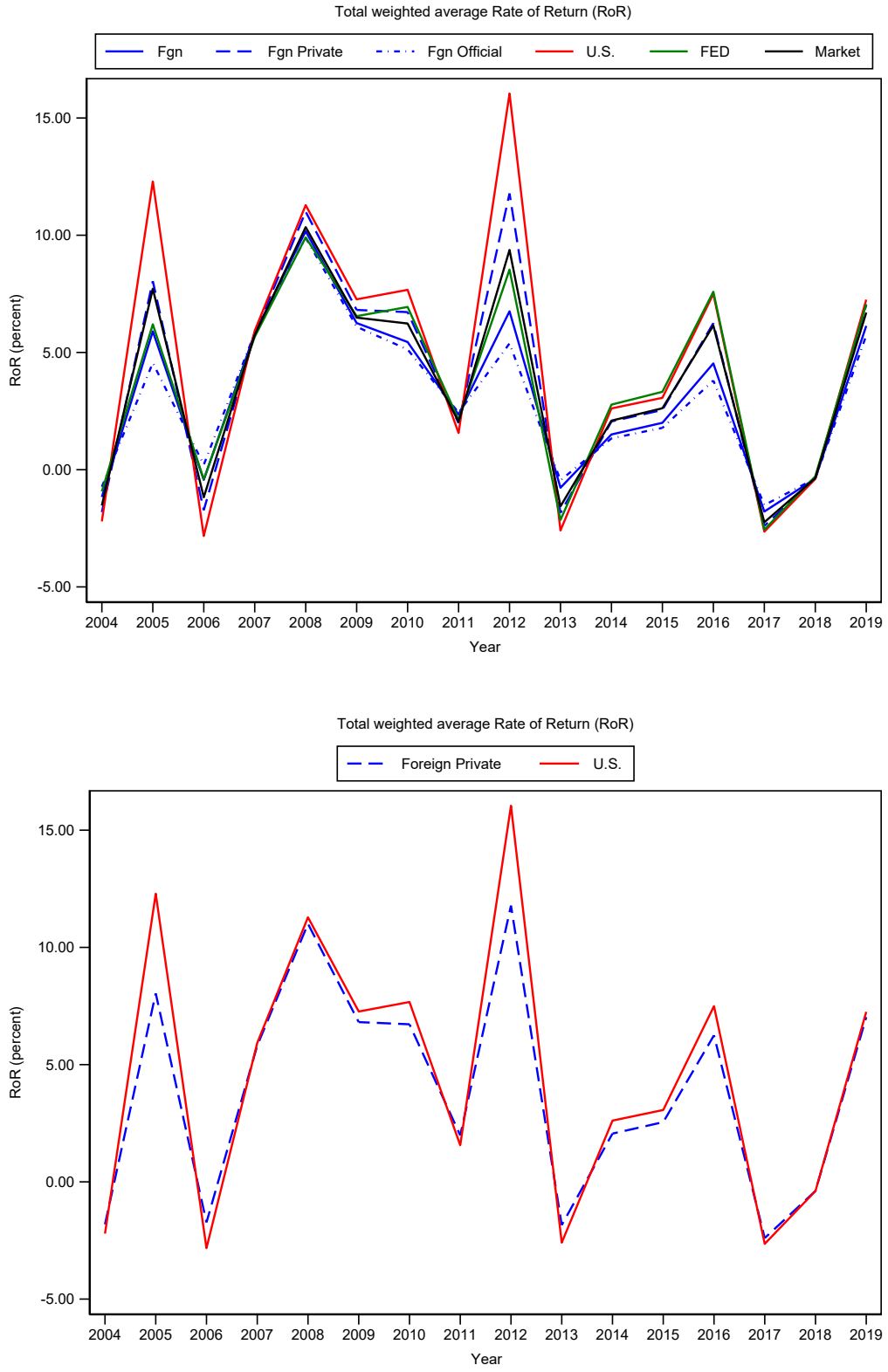
The top figure plots weighted averages of yield-to-maturity by investor type for securities with 20- and 30-year original maturity. The bottom panel plots the difference between these investors' yield-to-maturity and the market. Market refers to all outstanding marketable Treasuries as reported by Treasury Direct. Sample excludes floating rate notes (FRN), Treasury inflation protected securities (TIPS), and securities maturing within one year.

Figure 9: Duration of Treasury holdings per investor type



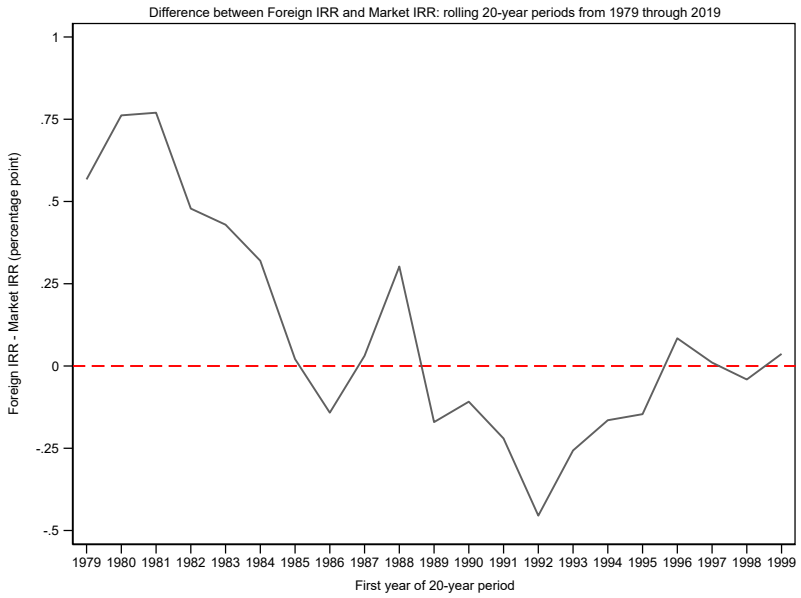
The figure plots weighted averages of duration by investor type. Market refers to all outstanding marketable Treasuries as reported by Treasury Direct. Sample excludes floating rate notes (FRN), Treasury inflation protected securities (TIPS), and securities maturing within one year.

Figure 10: Rate of return (RoR) of Treasury holdings per investor type, simple weighted average of all maturities



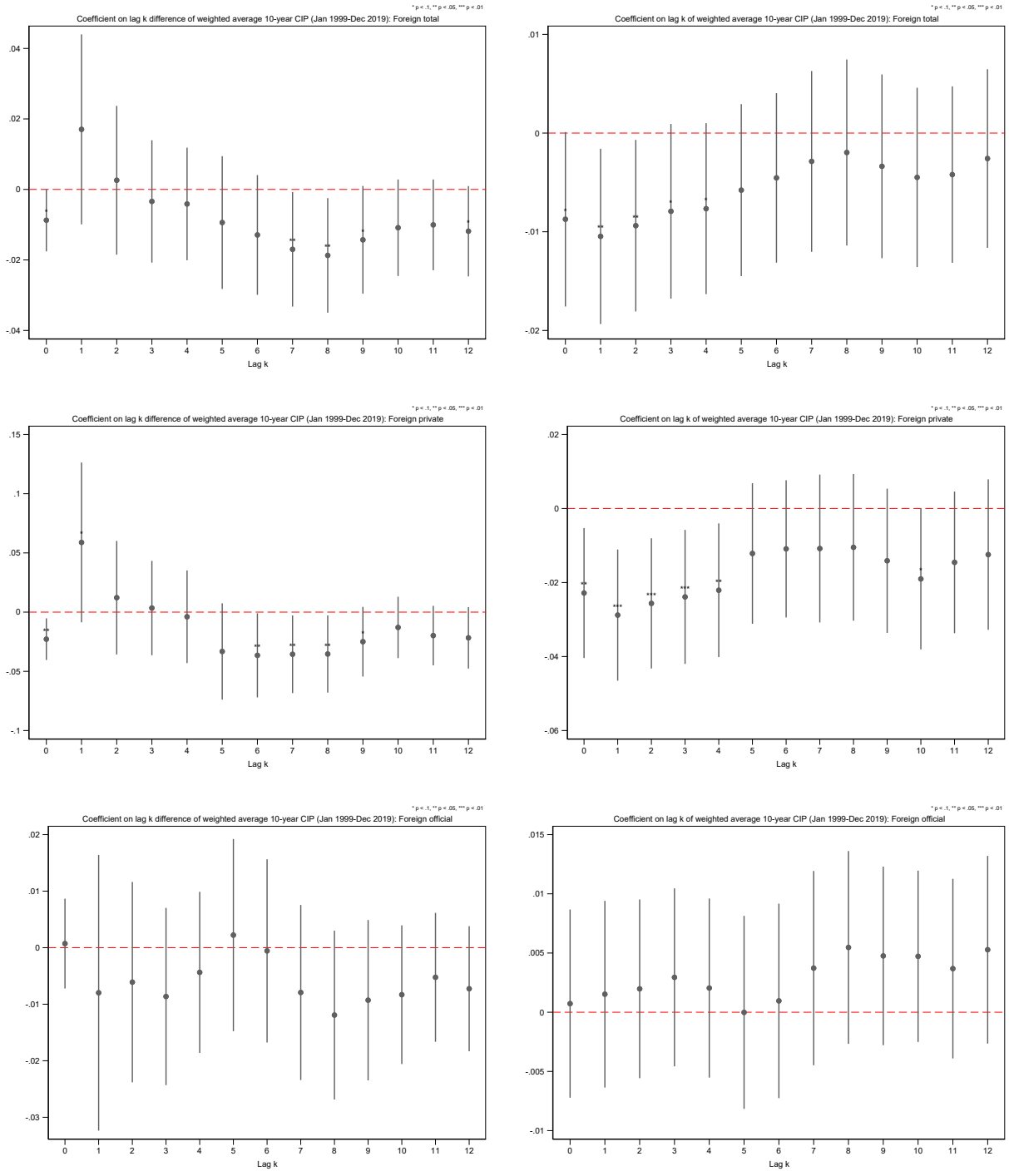
The figure plots weighted averages of the rate of return (RoR) by investor type. Market refers to all outstanding marketable Treasuries as reported by Treasury Direct. Sample excludes floating rate notes (FRN), Treasury inflation protected securities (TIPS), and securities maturing within one year.

Figure 11: Internal Rate of Return (IRR) on Foreign Investors' Treasury holdings and the Market: rolling 20-year periods



The figure plots the difference between foreign investors' IRR on their Treasury portfolio and the market Treasury IRR for rolling 20-year periods starting in 1979 through 1999. The last data point shows the difference between the foreign and market IRR for the period 1999-2019. Data: quarterly 1979q4-2019q2.

Figure 12: CIP deviations and foreign flows into Treasuries



The left figures plot the coefficients on the lag k difference of the G10 10-year CIP deviation from equation 8 in the text for total foreign flows (top panel), foreign private flows (middle panel), and foreign official flows (bottom panel). The right figures plot the coefficients on the lag k G10 10-year CIP deviation from equation 9 in the text for total foreign flows (top panel), foreign private flows (middle panel), and foreign official flows (bottom panel). The x-axes denote k used for the lag k differences (left panels) or lag k levels (right panels) of the CIP deviation. The G10 CIP deviation is the weighted average of the G10 currencies using the respective countries' Treasury positions. Sample period: January 1999 - December 2019.

Table 1: Total Rate of Return (RoR) on Treasury Securities Using Security-Level Data 2003-2019 (percent)

	RoR	RoR with adjustments	
		Belgium	Cayman
	(1)	(2)	(3)
Market	3.59	3.59	3.59
Federal Reserve	3.70	3.70	3.70
	(0.94)		
Float (Mkt-Fed)	3.55	3.55	3.55
	(0.98)		
Foreign Investors	3.21	3.21	3.20
	(0.78)		
Official	3.02	3.04	3.02
	(0.66)		
Private	3.77	3.80	3.77
	(0.90)		
U.S.	4.34	4.34	4.31
	(0.65)		

The table shows for the period June 2003 to June 2019 the geometric mean of the annual rate of return on Treasury holdings per investor type, calculated using the TIC survey security-level sample. Returns are weighted averages calculated using security-level price and interest payments data; we use security holdings as weights. The market rate of return is calculated in the same way using data on outstanding Treasury securities. In column (1) in parentheses are p-values for the test that the difference of means in RoR between each investor type and the market is not equal to zero. Robustness checks are reported in columns (2) and (3). For the return calculations in column (2) we shift Belgium's private holdings of Treasuries to the official investors' portfolio. In column (3) we shift Cayman Islands' holdings from the foreign to the U.S. portfolio.

Table 2: Risk-Adjusted Excess Returns on Treasury Securities (2003-2019), in percent

	Foreign Private	Foreign Official	Foreign Total	U.S.	Fed	Market
Risk-Adjusted	0.49	0.54	0.52	0.48	0.55	0.51
Mean Excess Return	2.20	1.46	1.65	2.76	2.13	2.02
StDev	4.47	2.70	3.14	5.76	3.86	3.93

The table shows, for the market (calculated using data on outstanding marketable Treasuries as reported by Treasury Direct) and by investor type, the geometric mean, standard deviation and risk-adjusted (calculated as geometric mean divided by standard deviation) returns. All returns are in excess of the one-year Treasury yield.

Table 3: Internal Rate of Return (IRR) on U.S. Treasury Purchases, in percent

Data source	TIC Survey			BTBJ
	market & face value	market & face value	market value	market value
	security-level	aggregate	aggregate	aggregate
	(1)	(2)	(3)	(4)
Market	2.71	3.15	3.15	3.14
Fed	3.93	3.60	3.92	3.91
Float (Market-Fed)	2.35	3.08	3.02	2.96
Foreign Investors	2.52	3.14	3.22	3.24
Official	2.58	3.21	3.29	3.34
Private	2.36	2.98	3.05	3.02
U.S.	2.23	2.90	2.61	2.58

The table shows the internal rate of return (IRR) results for 2003q2-2019q2. Column (1) uses the security-level TIC survey (SHL) data for the market value of initial and terminal positions, the face value of initial and interim positions (in order to calculate the interim coupon payments), and our survey-implied flows. For each period the coupon payments are calculated using the security-level information on coupon yields and face value. In columns (2)-(4) coupon payments are calculated by multiplying coupon yields from the ICE BoA Merrill Lynch Treasury index by the aggregate value of positions. Column (2) uses annual (end-June) TIC survey (SHL) data for the market value of initial and terminal positions, the face value of initial and interim positions (in order to calculate the interim coupon payments), and our survey-implied flows. In column (3), to calculate the interim coupon payments we use the market value of positions, not the face value. In column (4) we use quarterly BTBJ data for positions and flows. All rates are annualized.

Table 4: **The Duration of Foreign Investors' Treasury Holdings and Interest Rates**
The table shows panel (country-year) regression results. The dependent variable is the weighted average duration of Treasury bond holdings by foreign private (columns 1-4) and foreign official (columns 5-8) investors. Independent variables include sovereign local currency 10-year bond yields (Sov10y), synthetic dollar sovereign yields (10yrSynSov), and the Synthetic Difference (10yr SynDiff, synthetic sovereign yield minus U.S. Treasury yield). All yields are in changes. Sample excludes Belgium, Ireland, and Luxembourg (BIL). All specifications include country fixed effects. Time fixed effects are included in columns 1 and 5. Standard errors are clustered on country.

	Foreign Private				Foreign Official			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D.10yr SynDiff	-0.157***	-0.139***			0.005	0.016		
	(0.047)	(0.044)			(0.029)	(0.029)		
D.10yr SynSov			-0.139***				0.012	
			(0.043)				(0.026)	
D.US 10yr			0.142	0.010			-0.043	-0.121
			(0.127)	(0.122)			(0.088)	(0.078)
D.Sov10y				-0.088				0.097*
				(0.080)				(0.055)
Observations	451	451	451	547	445	445	445	532
Adj R-sq	0.35	0.35	0.34	0.34	0.41	0.41	0.41	0.44
Time FE	Yes				Yes			

Table 5: **The Duration of Foreign Investors' Treasury Holdings, Interest Rates, and the Insurance and Pension Fund Sectors**

The table shows panel (country-year) regression results. The dependent variable is the weighted average duration of Treasury bond holdings by foreign private (columns 1-4) and foreign official (columns 5-8) investors. Independent variables include sovereign local currency 10-year bond yields (Sov10y), synthetic dollar sovereign yields (10yrSynSov), the Synthetic Difference (10yr SynDiff, synthetic sovereign yield minus U.S. Treasury yield), and ICPF (an indicator variable that equals one if the size of a country's insurance companies and pension funds sector, measured as the size of the sectors assets relative to total domestic assets, is higher than the sample median). All yields are in changes. Sample excludes Belgium, Ireland, and Luxembourg (BIL). Time fixed effects are included in columns 1 and 5. Standard errors are clustered on country.

	Foreign Private				Foreign Official			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D.10yr SynDiff	-0.168***	-0.160***			-0.021	0.003		
	(0.029)	(0.020)			(0.027)	(0.020)		
High ICPF=1	0.481	0.467	0.433	1.073*	-0.280	-0.319	-0.322	-0.195
	(0.612)	(0.596)	(0.606)	(0.640)	(0.354)	(0.356)	(0.357)	(0.334)
High ICPF=1 × D.10yr SynDiff	0.162	0.221			0.231	0.226		
	(0.569)	(0.375)			(0.368)	(0.277)		
D.10yr SynSov			-0.149***				-0.004	
			(0.014)				(0.020)	
High ICPF=1 × D.10yr SynSov			0.188				0.223	
			(0.355)				(0.247)	
D.US 10yr			0.262	0.013			-0.080	-0.117
			(0.181)	(0.212)			(0.095)	(0.109)
High ICPF=1 × D.US 10yr			-0.543	-0.184			-0.251	-0.445
			(0.399)	(0.223)			(0.279)	(0.355)
D.Sov10y				-0.184***				0.045
				(0.017)				(0.050)
High ICPF=1 × D.Sov10y				0.078				0.616*
				(0.104)				(0.331)
Observations	254	254	254	288	246	246	246	282
R-sq	0.08	0.02	0.03	0.06	0.07	0.01	0.01	0.03
Time FE	Yes				Yes			