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ABSTRACT

While foreigners are prominent in the Treasury market and in theoretical and empirical work, little is known about the nature of their Treasury portfolios. We provide novel evidence on foreigners' U.S. Treasury portfolios based on data not yet used by researchers: the security-level Treasury portfolios of foreigners and private U.S. investors. We find that private foreign investors earn above market returns and on a risk-adjusted basis both foreign private and foreign official investors outperform U.S. investors. Moreover, while foreign officials, with their broader objective functions, may well have inelastic demand, private foreign investors increase purchases of Treasuries and increase the duration of their Treasury portfolios when their sovereign yields are low or decrease relative to Treasury yields (that is, when CIP deviations decrease). Our results are so different from existing results that we close with a reconciliation exercise that provides a useful assessment of different sources of data on flows and holdings.

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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 the world's safe asset and have money-like qualities that confer a non-pecuniary benefit, the convenience yield (Krishnamurthy and Vissing-Jorgensen (2012)).

Foreign investors are prominent in the Treasury bond market, holding just under half 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. The notion that foreigners have poor performance in their Treasury portfolios underlies two influential literatures. Foreigners' low returns on U.S. bonds is at the heart of the U.S. exorbitant privilege (Gourinchas and Rey (2007)) and their poor timing, poor performance, and inelastic demand are often presented as proof that U.S. Treasuries have a sizeable convenience yield (see Krishnamurthy and Lustig (2019), henceforth KL, and Jiang, Krishnamurthy, and Lustig (2021), henceforth JKL).[2]

While foreigners are prominent in the Treasury market and in theoretical and empirical work, little is known about the nature of their Treasury portfolios, whether their performance can be characterized as poor, or if their demand can be characterized as inelastic. There is

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

[2] See also Jiang, Krishnamurthy, and Lustig (2018).

a simple reason behind this: Studies tend to use publicly available data that are at a level of aggregation that limits most analysis and, arising from different data collection systems, are not always in agreement across sources. In practical terms, different data sources are often brought together to form datasets that are not internally consistent. For example, in the literature on current account sustainability, that there is a by-asset-class returns differential (a so-called returns effect) that could be characterized as exorbitant is a product of using positions and flows data that are not internally consistent (Curcuru, Dvorak, and Warnock (2008), Curcuru, Thomas, and Warnock (2013)).[3] And one prominent theme in the convenience yield literature - that foreigners have very poor performance in their Treasury portfolios – is also based in part on inconsistencies within datasets; in that literature, the implied returns that foreigners earn on their Treasury portfolios are, as in the exorbitant privilege literature, spectacularly low.

In this paper we take a step back and assess the empirical support for mechanisms attributed to foreign investors that underlie leading theories. At the heart of our study is a rich security-level dataset on foreign holdings of U.S. Treasuries for the period 2003-2019. The data are from security-level annual surveys on cross-border portfolio investment in the United States conducted through the U.S. Treasury International Capital (TIC) System. Given that reporting to the surveys is mandatory, the data we use are comprehensive; they capture, at the individual security level, foreign countries' entire portfolios of U.S. Treasuries.[4] Our study focuses on the security-level data on foreigners' Treasury portfolio and, because we also know the security-level holdings of the Federal Reserve and the amount outstanding of

[3]In Section 4 we are more precise about the nature of the inconsistency. Briefly, it is often due to an assumption, usually incorrect, that holdings and flows form a dataset from which returns can be directly estimated; on this point see also Gohrband and Howell (2015). Other times inaccurate flow series are used.

[4]The security-level data are confidential, but various aggregations 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 to 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).

each Treasury bond, we can form as a residual private U.S. investors' security-level Treasury holdings. Thus, our study is an exploration into the Treasury portfolios held by private foreign investors, foreign governments, and U.S. private investors.[5,6]

Directly computed portfolio returns yield results that are strikingly different from those in the existing literature. For example, focusing on private foreign investors, KL find that foreigners' Treasury returns are almost 500 basis points less than the market. In contrast, we find that over the period June 2003 - June 2019, private foreign investors' returns (3.77 percent per annum) exceeded market returns (3.59 percent). And while foreign official investors' returns (3.02 percent) were lower than market returns, the gap is relatively small at just 57 basis points. U.S. private investors (4.34 percent) had higher than market returns. The differences across investor type appear small and they are: None is statistically different from any other.

We investigate further by noting that performance differences can be due to some combination of skill/timing and taking on different levels of risk. We show that the modest differentials we find are due to the latter. For timing, we calculate the yield-to-maturity (YTM) of every bond of a certain maturity to see, for example, if foreign private investors have a lower YTM on their 7-year bonds (which would be evidence they bought them at the

[5]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.

[6]For completeness, we also report results for the Fed's Treasury portfolio, although the Fed does not attempt to maximize returns on Treasuries and its motivation in buying Treasury securities is quite different from other investors'. 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 Sept 2011 until June 2012 - the Fed deviated from this by purchasing the long end and selling the short end.

"wrong" time). We see no meaningful persistent differences across investors, except at the long end of the curve (20-30 years).[7] On risk, however, there are noticeable differences. In particular, U.S. private investors have a much longer duration Treasury portfolio than others. This additional risk propelled their returns. In fact, Sharpe ratios (calculated as mean excess returns divided by their standard deviation) indicate that foreign official investors perform better than foreign and U.S. private investors. That said, as with raw returns, the differences in Sharpe ratios are not statistically different across investor type.

We also assess how private and official foreigners alter their U.S. Treasury portfolios when interest rates change. Using another dataset on aggregate monthly flows we show that private foreigner investors, but not foreign officials, increase their flows into U.S. Treasuries when CIP deviations (the synthetic sovereign dollar yield minus the Treasury yield, which is the opposite of the Treasury basis) are low or have fallen. And, using country-level regressions of weighted-average duration (built from the security-level holdings and security characteristics), we find that private foreign investors, but not foreign official investors, lengthen the duration of their Treasury portfolios when CIP deviations decrease. The analyses of flows and duration provide evidence that private foreign investors, but not foreign officials, have elastic demand for Treasuries.[8]

Our security-level and aggregate analyses show that private foreign investors perform quite well, earn similar yields as other investors on similar maturity bonds (which is inconsistent with bad timing), on a risk-adjusted basis perform better than U.S. investors, and, consistent with elastic demand, increase purchases and the duration of their Treasury portfolio when CIP deviations decrease. Foreign officials, with much broader objective functions,

[7]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. private 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 bonds were only 4 percent of foreign officials' Treasury portfolios.

[8]These results are consistent with the finding in Krishnamurty and Vissing-Jorgensen (2007) that private foreign investors are more price elastic than official investors and with the Greenwood et al. (2020) model in which changes in sovereign yields lead to new flows.

appear to be price insensitive but do not seem to pay for this, as their Sharpe ratios are higher than other investor types'.

Therefore, our analysis shows no support for the notion that foreign investors have poor performance and, other than foreign officials, inelastic demand. Our results are so different from those in the existing literature that in the penultimate section we include an extensive reconciliation exercise. The exercise requires a deep dive into different sources of data on flows and holdings. Ancillary contributions from this deep dive include an assessment of different sources of publicly available data that should prove useful to many researchers going forward as well as an informative presentation of Treasury flows and holdings by investor type. Our reconciliation exercise shows that using the best possible data eliminates much of the sizeable returns differentials found in the existing literature.[9]

The paper is as follows. In the next section we first present directly measured returns on the Treasury portfolios of foreigners and U.S. investors and then examine reasons behind the performance differences. In Section 3 we demonstrate how foreign investors alter their Treasury portfolios in response to changes in yields. In Section 4 we conduct a reconciliation exercise to ascertain the reasons behind the sharp differences between our results and existing ones. Section 5 concludes.

2 Returns on U.S. Treasury Bond Portfolios

A prominent presumption in the existing literature is that in their U.S. Treasury bond portfolios foreigners have inelastic demand, poor timing and low returns. That might be true. But it might not be. The returns that figure prominently in existing studies are inferred from publicly available aggregate data, and it is not obvious that existing returns

[9]Specifically, as we detail in Section 4.2, correcting errors in returns series used in the literature reduces the 500 basis point gap reported by Krishnamurthy and Lustig (2019) by 250 basis points, comparing IRRs with IRRs (as opposed to IRRs vs. market returns) reduces the gap by another 125 basis points, and not assuming zero holdings at t=0 and using best quality flow data reduces the gap by another 30 basis points.

calculations are accurate.

In this section we examine the evidence provided by direct measures of foreigners' security-level Treasury portfolios. Specifically, we use the security-level data to observe, as of each June 30th since 2003, the portfolios of private and official foreign investors. We also use the Federal Reserve Bank of New York SOMA data to bring in 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. private investors' holdings as the residual: total outstanding less foreign and Fed holdings. With those portfolios, and assuming investors reallocate only on June 30th of each year (the day we observe foreign portfolios), we can compute returns for each type of investor.

2.1 The Security-Level Portfolio Data

The security-by-security data on foreigners' Treasury portfolios, collected by the U.S. Department of the Treasury as part of the TIC reporting system, underlie the annual U.S. TIC benchmark surveys of foreign holdings of U.S. securities and feed into official BEA data on the U.S. international investment position (and the 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, i.e., they capture the entire foreign portfolio of U.S. Treasuries at the individual security level.

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 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.[10]

The security-level data are annual, reported as of June 30 of each year for each foreign country's holdings of security b. 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).[11]

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 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.

In addition, in this paper there are three main calculations we do with the security-level data: From prices and payment terms, we calculate the bonds' total return, yield-to-maturity,

[10]We can also directly (and easily) compute the security-level flow - that is, net purchases - as the change in the position (which is observed) less the valuation adjustment (which is directly computed).

[11]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.

and duration at each end-June date. We check that these are the same as the ones reported per security in the constituent files of the BofA Merrill Lynch index. For robustness we also checked using the index data for matched securities combined with our calculated series for unmatched securities; since all data are very close, the results are the same.

In sum, the security-level data we use represent the universe, to the extent it is known.

2.2 Directly Measured Returns

We compute returns as the return on each Treasury bond weighted 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. private, or the entire market.[12] $\text{RoR}_{b,t+1}$ is bond b's annual rate of return from year t to year $t+1$. The weight $\omega_{b,i,t}$ is holdings of particular bond $\text{H}_{b,i,t}$ relative to total holdings per investor i at time t:[13]

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

Results are in Table 1. Using directly observed portfolios, over the period June 2003-June 2019 private foreign investors had returns (3.77 percent per annum) that exceeded market returns (3.59 percent). The fact that private foreign investors earn higher than market returns is not consistent with the poor performance / inelastic demand notion that is used to support some convenience yield theories. U.S. private investors (4.34 percent) also

[12] For completeness, we also report results for the Fed's Treasury portfolio.

[13] 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.

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, we find that 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 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.[14] In column (3) we shift Cayman Islands' holdings from the foreign to the U.S. private portfolio, as it is possible that funds in the Cayman Islands are predominantly associated with U.S. operations. This shift lowers U.S. private returns a touch and foreign private returns do not change.

2.3 Factors Behind the Directly Measured Performance Differentials

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

2.3.1 Yield at Different Maturities

We start our investigation by eliminating the effect of maturity choice on each portfolio's yield. That is, we can 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

[14]Results are similar if we exclude Belgium's private holdings.

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. If an investor has bad timing, 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 present the yield-to-maturity (YTM) of each investors' portfolio of Treasury bonds of 3-, 5-, 7-, and 10-year original maturity in Figure 1 and 20-30-year maturities in Figure 2.

Focusing first on Figure 1 we see that 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 2) does the spread widen much (to 50bps); even so, there are not many bonds (less than 20 percent) in this bucket.

So 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. For 5-year bonds, U.S. Private did best 2007-2017 (but never more than 12bps from market), while Foreign Private was next best and Foreign Official was worst (but never more than 12bps below market). For 7-year bonds, U.S. Private was consistently best, with Foreign Private a very close second, and Foreign Official consistently lower. For 10-year bonds, U.S. Private 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. Private had the highest yields starting in 2009, often 20bps better than market (and in 2011: 40bps),

Foreign Official had the lowest, and Foreign Private was pretty much right at market.[15]

Overall, an examination of the YTMs of bonds of certain maturities does not indicate that private foreign investors have poor performance. The yields by maturity bucket in their Treasury portfolios are similar to other investors'.

2.3.2 Duration

We next turn to the riskiness of the portfolios. In particular, we focus on duration (Figure 3). 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. private 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) was 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 directly measured returns presented in Table 1. U.S. private 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).

We compute Sharpe ratios in Table 2. Sure enough, the higher returns earned by U.S. private 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.

[15] 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.

2.4 Summary of Returns Differentials

Overall, the story of foreign investors that emerges from Tables 1 and 2 and Figures 1-3 is substantially different from what is often portrayed in the safe asset / convenience yield literatures, where foreigners' Treasury portfolios earn substantially less than market returns - with the gap being over 100bps, even 200bps, sometimes almost 500bps - ostensibly because foreigners put substantial value on the convenience properties of holding Treasuries. While at times the literature focuses on all foreigners (Jiang, Lustig, van Nieuwerburgh and Xiaolan (2020)), often its focus is on private foreign investors (KL, JKL). But direct observation of the yields on each and every Treasury bond in foreigners' portfolios shows quite a different story: the average annual 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. private investors hold the longest duration portfolio, and that portfolio had by far the most volatility; U.S. private investors had the lowest Sharpe ratio, while the short-duration foreign official portfolio had a high Sharpe ratio.[16] If existing literatures rest on foreigners accepting lower yields, Table 1 and 2 and Figures 1-3 show striking counterevidence.

3 On Foreigners' Inelasticity

It is often posited that foreigners have inelastic demand for U.S. Treasuries, and this inelasticity is put forward as evidence of a sizeable foreigner-specific convenience yield. We

[16] 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.

address this in two ways in this section. First, we recognize that our annual data, while detailed, have limitations in an analysis of elasticity. For example, if foreigners have sizeable net purchases, then contemporaneous 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 another dataset for high quality higher frequency (monthly) but aggregate flow data that is better suited to capture leads and lags in the relationship between flows and yields. We do that in Section 3.1. Then in Section 3.2 we examine another dimension of elasticity by utilizing a novel aspect of our security-level data: Even in the absence of flows we can see how foreigners alter their Treasury portfolios by examining how foreign investors change the duration of their portfolios when spreads change.

In both analyses in this section we will make use of data on CIP deviations from Du and Schreger (2016) and Du, Im, and Schreger (2018).[17] 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, also called the CIP deviation, is the negative of the KL Treasury basis.

3.1 Foreign Flows and Yields

Do foreigners 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 flow data. We provide more details on the flow data in Section 4.1.2, where we assess the quality of flow data from different sources. For now we will note the series use the high quality but low frequency positions surveys to adjust the higher frequency flow data. The source of the

[17]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.

monthly flow and positions data, which we refer to as BTBJ, is Bertaut and Tryon (2007) and Bertaut and Judson (2014).[18]

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:

$$\text{Flow}_t/\text{Position}_{t-1} = \alpha + \beta(\text{CIP}_t - \text{CIP}_{t-k}) + \epsilon_t \tag{3}$$

$$\text{Flow}_t/\text{Position}_{t-1} = \alpha + \beta\text{CIP}_{t-k} + \epsilon_t \tag{4}$$

In Figure 4 we plot the β coefficients from each time series regression we run for each k lag. Each plot in Figure 4 shows, from 24 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 1 to 24 months. Lags are cumulative changes (left column, corresponding to eq. (3)) or simple levels (right column, corresponding to eq. (4)). 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. 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 total foreigners, this relationship holds at 1-3 month lags of levels (right column)

[18] Vissing-Jorgensen (2021) 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. We assess the quality of different data in Section 4.1.2.

and cumulative lags of changes from 6 to 24 months (left column). The total foreign results are driven by private foreigners; the middle row of graphs are very similar to the those in the top row. In contrast to total foreign and private foreign, foreign officials do not seem to adjust their net purchases based on the levels of or changes in CIP deviations; there are some statistically significant coefficients for foreign official flows, but these are at very long lags of a year and a half or longer and are likely statistical artefacts. Overall, the evidence in Figure 4 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 Krishnamurty and 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 recent KL and JKL findings that foreigners have inelastic demand.

3.2 Duration

We can use the security-level data to gauge another aspect of foreign investors' behavior with respect to their U.S. Treasury bond portfolios. That is, rather than focusing on the level of flows, we can ascertain the extent to which foreigners alter their Treasury portfolios when there are changes in the sovereign rate, the synthetic (i.e., CIP-adjusted) sovereign rate and the Treasury rate. Specifically, we assess in Table 3 how the duration of their Treasury portfolio adjusts to these variables.

The panel regressions we run are as follows:

$$\text{Dur}_{j,t} = \alpha + \beta \Delta 10\text{yr SynDiff}_{j,t} + c_j + \eta_t + \epsilon_{j,t} \tag{5}$$

$$\text{Dur}_{j,t} = \alpha + \beta \Delta \text{Y}_{j,t} + \Delta \text{Y}_t^{\text{US 10yr}} + c_j + \epsilon_{j,t} \tag{6}$$

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 similar to the aggregation in equation (1). In equation (5) the explanatory variable, 10yr SynDiff, is country j's synthetic yield difference (synthetic sovereign yield minus U.S. Treasury yield). In equation (6), 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. 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.[19] All specifications include country fixed effects (c_j); time fixed effects (η_t), are included in columns 1 and 5 (corresponding to equation (5)); 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 changes in their own sovereign yield: When the sovereign yield increases, foreign officials

[19] 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.

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 4).

Overall, results in Tables 3 and 4 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. Again, 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'.[20]

4 A Reconciliation Exercise

Our results differ starkly from results in the existing literature. The 38 basis points differential between (private plus official) foreigners' returns and market returns, and the facts that private foreign investors beat the market and foreign officials have a high reward-to-risk ratio, are inconsistent with the nearly 500 basis points differential in KL and the lower but still sizeable 200 basis points differential in JKL. In this section we reconcile our results with existing estimates.

[20]The results are also consistent with the notion (that we cannot confirm) that private foreigners hedge their Treasury portfolios while foreign officials do not.

4.1 The Data and Methodology of the Existing Literature

Existing studies use publicly available data on positions and/or flows and a Treasury bond index to compute implied returns using a technique based on Dichev and Yu (2011).[21]

4.1.1 The Methodology

Dichev and Yu (2011) strived to compute 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. They did so by viewing a hedge fund investment as a capital project, where the initial investment and intermediate capital contributions are capital inflows, and capital distributions and ending AUM are capital outflows. The intermediate capital contributions are computed as:

$$\text{Capital Inflows}_t = \text{AUM}_t - \text{AUM}_{t-1}(1 + \text{r}_t) \tag{7}$$

where r_t is funds' reported net-of-fees return. Solving for the internal rate of return (IRR) of this time-ordered schedule of capital flows yields the dollar-weighted return on this investment.[22] 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, the initial investment is the value of foreigners' initial holdings, the intermediate contributions or capital inflows are net purchases each period, capital distributions are the income stream of coupon payments, and the terminal payout is the value of bond holdings at the end of the sample. For example,

[21] We are indebted to Hanno Lustig for pointing this out to us and for providing the returns series used in KL and JKL.

[22] While textbook corporate finance warns on the pitfalls of using IRRs, because among other issues they can have multiple solutions, Dichev and Yu (2011) use IRRs because of data limitations. In particular, they wanted to measure investors' returns but had only fund-level information. Our directly measured returns in Section 2 do not have that limitation.

to compute foreigners' IRR for a sample period of 1980 through 2019, the initial investment is their holdings of Treasury bonds at end-1979 (assumed to all be purchased at end-1979), intermediate contributions are their net purchases from 1980 through 2019, intermediate distributions are coupon payments each period from 1980 through 2019 (computed from a Treasury index coupon yield applied to the previous period's face value of holdings), and the final payout is equal to the amount of their holdings as of end-2019.

Since we observe the security-level portfolio and directly computed returns in Section 2, we do not need to use this methodology. But we will do so in an attempt to better understand differences between our results and those in the existing literature. The first step is to decide which data sources to use.

4.1.2 The Data

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:

$$\mathrm{A}_t = \mathrm{A}_{t-1}(1 + \mathrm{r}_t) + \text{Net Purchases}_t \tag{8}$$

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:

$$\mathrm{A}_t = \mathrm{A}_{t-1}(1 + \mathrm{r}_t) + \text{Net Purchases}_t + \text{Other Adjustments}_t \tag{9}$$

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.[23] We will keep this in mind

[23]Indeed, the Curcuru, Thomas, and Warnock (2013) view of the early literature on exorbitant U.S. returns differentials is that researchers ignored an OA that was at times substantial. Gohrband and Howell (2015) also note that OA should not be considered returns.

as we discuss the various data sources.

Data on foreigners' positions are typically from the Federal Reserve's Financial Accounts of the United States (formerly known as Flow of Funds (FOF)) Table L.210.[24] There are other sources for these data, but as we will show, the source of the positions data is not that important because publicly available sources have very similar positions series. Flows are a different story. Data on flows differ across sources and are where researchers' decisions can meaningfully impact results. For flows researchers typically use FOF Table F.210 or, when the focus is on private foreign flows, TIC S data. For example, KL and JKL focus on private foreign investors and thus use TIC S for flows, while Jiang, Lustig, van Nieuwerburgh, and Xiaolan (2020), focusing on all foreign investors, use FOF flows data.

Positions

Stepping back, there are three main sources of foreigners' positions in U.S. Treasuries. One - the now annual security-level TIC survey (henceforth TIC SHL), conducted each year as of end-June - is the primary input for the others: BEA's IIP data (quarterly since 2006, prior to that year-end) and the Federal Reserve's quarterly FOF data.[25] Each source presents very similar numbers for *positions*, as one (the TIC SHL survey of foreigners' holdings of U.S. securities, which we used in Section 2) is the primary input into the others. As Figure 5 (top panel) shows, 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.[26] 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 5, bottom panel). There are minor differences - BEA puts a little more in private holdings,

[24] In the remainder of the paper we use FOF to refer to the Financial Accounts of the United States data.

[25] BEA's IIP data is at https://www.bea.gov/data/intl-trade-investment/international-investment-position, FOF is at https://www.federalreserve.gov/releases/z1/. TIC SHL has been conducted every 5 years starting 1974 and annually since in 2003.

[26] 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, all holdings sources provide very similar amounts, with 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.[27]

Flows

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 transactions data. 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.[28]

Figure 6 (top panel) shows that BEA's BOP and the Federal Reserve's FOF are identical

[27]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 reported at an aggregate level and are similar to the aggregated SHL annual data.

[28]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. On issues with TIC S transactions data, see Griever, Lee, and Warnock (2001) and Warnock and Cleaver (2003), among others. For more details on the relationship between BEA and TIC S flows, see Bureau of Economic Analysis (2019).

- it is barely discernable that the lines differ - but that TIC S flows differ substantially. For 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 6, bottom panels). As FOF does not present this split, we focus on TIC S and BEA's BOP. BEA BOP data (Figure 6, bottom left) show that through 2012 the bulk of foreign flows into U.S. Treasury bonds were from official investors, whereas TIC S (Figure 6, 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.

Going back to the IRR exercise, we can see that data choices will matter, but 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.[29]

An Assessment

There is a direct way to ascertain which series should be used, albeit one that is only available since 2003. The comprehensive annual surveys of foreigners' holdings is the single most accurate source. Other agencies seem to agree; recall from Figure 5 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. 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 excludes price change effects)

[29]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).

and market values of holdings. Armed with those we can accurately calculate the valuation change on each and every U.S. Treasury bond - which we used in Section 2 to compute returns - 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 7 (top panel) shows, our implied flows are closest to the BEA and FOF flow series and differ greatly from TIC S flows. The evidence suggests that researchers should use either FOF or BEA (which are identical).[30]

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 7, 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 JKL and He, Nagel and Song (2021), among others - differ substantially from our implied flows and BEA-reported flows.

Figure 8 brings in another source, one that is by construction internally consistent. For the past two decades the Federal Reserve's International Finance Division has used the high-quality annual positions surveys to improve flow data and create internally consistent dataset on monthly positions, flows, and valuation adjustments (Thomas, Warnock, and Wongswan (2004), Bertaut and Tryon (2007), Bertaut and Judson (2014)). For Treasuries the aggregate

[30]That the TIC S flow data should not be used has been recognized for at least two decades. For example, Warnock and Cleaver (2003) noted significant problems with the TIC data on U.S. bonds. Many of the problems pertain to the bilateral flows, but there have been substantial issues with aggregate flows too.

series for private and official foreign investors are currently available December 1978 - June 2019; country-level estimates are available starting December 1984. As Figure 8 shows, the positions from what we call BTBJ 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) data provide a publicly available internally consistent series on positions, flows, and valuation adjustments.[31]

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

An Aside: What the Data Show

Foreigners as a group have the largest Treasury bond holdings (Figure 9). Over the past two decades 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. Within the set of foreign investors, foreign officials' Treasury holdings are about twice as large as private foreigners, although since 2012 foreign officials' holdings have been largely flat, mimicking global international reserves (which peaked in 2014Q2 and did not reach that level again until 2020Q3). 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-

[31]The flows and positions from BTBJ are what we used in the flow analysis in Section 3.1. Note too that, referring back to eq. (9), other datasets will inevitably include a non-zero OA. And 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.

2019. U.S. private investors' holdings, which we calculate as the residual, have fluctuated around 40 percent of the Treasury market over the past two decades.

Turning to the associated flows, which for readability we depict in Figure 10 as 3-year moving sums, foreigners were the largest source of flows until 2016, when U.S. private investors' flows began trending up and exceeding foreign flows. Within foreign flows, foreign official flows were the bulk of foreign flows early in the sample, but every year since 2014 private foreign purchases of Treasuries have exceeded officials' purchases. Fed purchases peaked 2011-2013 with some of the initial QE programs and by 2017 were zero or negative.

4.2 IRRs

In this subsection we compute IRRs using data on initial and ending positions, interim net purchases and estimated income streams. We do this for foreigners (separating out private and official foreign investors where possible), U.S. private investors, and the Fed (for completeness) over periods that end in 2019 and start in 1980 (to be consistent with KL), 1986 (when our foreign bonds returns index starts), and 2003 (to be consistent with our security-level analysis). U.S. private investors' holdings are calculated as the residual: total outstanding marketable Treasury bonds less foreign and Fed holdings. We also show the market rate of return (RoR) as given by the ICE BofA Merrill Lynch U.S. Treasury total returns index and a market IRR computed in the same manner as the other IRRs. Data are at market value, except in one instance where we use unpublished face value data to compute income streams.[32]

Table 5 presents the results. Two things to note before we turn to foreigners' returns. One, IRRs and RoRs are not directly comparable. For the period 1980q1 - 2019q2 (column 1), when we put market returns on the same footing as the IRRs - that is, instead of using an

[32]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).

index return, we calculate an IRR just as in other rows but using total (unadjusted) flows as reported in FOF - the market IRR (5.98 percent) is substantially lower than the index RoR (7.24 percent). In general, investors' IRRs are not directly comparable with a market RoR, as IRR is implied (and there is no information on the maturities being purchased) whereas the index return is built from actual security-level returns. Two, our Index RoR of 7.24 percent is over 300 basis points lower than the 10.33 percent reported, for the same period, in KL. Such a discrepancy is surprising for the most traded asset in the world. Table 6 explores this point. KL use Barclays Treasury index and report average annual returns that exceed 10 percent. We downloaded the Barclays index and get 7.2 percent, the same as ICE BofA Merrill Lynch.[33] The second line shows where the main difference is: The KL returns series has 29 percent annual return for the period 1980-1985, while other series show 14 percent for that period. After 1985 the series are much more similar. So our first conclusions in this reconciliation exercise are that RoRs are not directly comparable to IRRs and that the exceedingly high market RoR in KL is due to errors in the returns series, especially for the period 1980-1986.

Back to Table 5, for the period 1980q1 - 2019q2 column (2) is the most accurate for the simple reason that BTBJ is an internally consistent dataset of positions, flows and returns. BEA data and, hence, FOF data include Other Adjustments. That is, BTBJ satisfy equation (8), while FOF (which relies on BEA data) has a discrepancy between the left and right sides of that equation. The discrepancy, called Other Adjustments in other settings, means that pre-2003 FOF shouldn't be used to create IRRs. In column (2), foreigners' returns are 4.97 percent (slightly higher for private foreigners, slightly lower for foreign officials), compared to the market's IRR of 5.98 percent. The 101 basis point difference is a long way from the 500 basis points in KL and embedded in JKL. In our view, about 250 basis points of the

[33]We also checked Aswath Damodaran's NY Stern web site (http://pages.stern.nyu.edu/ adamodar) for historical returns. Using the annual data from that site, we calculate about 7.35 percent average annual returns, similar to our calculation using the quarterly ICE BofA Merrill Lynch index.

discrepancy comes from errors in the returns series used in KL and JKL and another 125 basis points come from comparing an index RoR with an IRR.[34]

Another comparison JKL make is foreigners' returns on U.S. Treasuries compared to their returns on their own bonds, arguing that the fact that foreigners earn so much more on their own bonds is evidence of Treasuries' specialness. To our knowledge, the first quarter for which a Global exUS bond index is available is 1986q1, so in column (3) we show our IRR and RoR calculations starting in 1986q1. As in other sample periods, private foreigners' IRR is similar to the market's, just 27 basis points below. And as in other sample periods, market IRR and index RoR is quite different. Comparing the Treasury index RoR of 6.09 percent for 1986q1-2019q2 with the Global exUS index RoR of 6.49 percent (Table 6), the gap (40 basis points) is again quite small. Foreigners do not have poor performance in Treasuries, and they do not earn much more on their own bonds.

The most accurate data in Table 5 is in column (4), where we use unpublished data on the face value of holdings to compute the intermediate income streams. Foreign investors' returns are similar to the market's.[35]

Overall, Table 5 does not support the notion that foreign investors earn below market returns. But implied returns are subject to error and so here we will restate the direct evidence from Table 1. Private foreign investors have slightly higher than market returns, foreign official slightly lower mean but a high Sharpe ratio.

[34]The existing studies also assume period 0 positions equal zero and cumulate forward flows and valuation adjustments. The choice of this method is due to the recognition that many datasets are internally inconsistent. But while this method creates an internally consistent dataset, it ignores the initial level of holdings and associated income streams and shaves 15 basis points off foreigners' returns. Poor quality flow data reduces foreigners' returns by another 15 basis points.

[35]We include columns (5) and (6) because the face value series in column (4) is not publicly available. Comparing column (4) with columns (5) and (6) indicates that using market value changes details but not the main takeaways.

4.3 Implications for the Convenience Yield Literature

A straightforward takeaway for the convenience yield literature is that the sizeable returns differentials reported in the literature do not exist when returns are directly measured. We found, using the best available data, that foreigners' Treasury portfolios earn returns comparable to other investors. We also found, using quality monthly flow data, that private foreigners respond to changes in spreads, counter to existing findings of inelastic demand.

But other ways our results impact the convenience yield are a bit more subtle. For example, another way JKL compute convenience yields is the difference between foreigners' returns in their own markets and returns on their Treasury holdings. That is, they compute $R^{**} - R^{\$*}$, where first subscript is foreign bonds (*) or U.S. Treasuries ($) and second superscript denotes investor (* here is private foreign). They find that the differential is 1.89 percent (JKL, page 1069). That is, private foreigners earn 1.89 percent per year more on their foreign bonds than on their U.S. Treasury bonds. But the comparison in JKL is of foreigners' IRR on Treasuries, computed from 1980q1 - 2019q2, with a market RoR on Global exUS sovereign bonds computed starting 1986q1. As we showed, RoRs and IRRs are not comparable, and if we compare Treasury RoR and Global exUS RoR from 1986q1 - 2019q2 we get a difference of about 40bps. According to JKL, $R^{**} - R^{\$*}$ is a direct measure of convenience yields $\lambda^{\$*} - \lambda^{**}$; if so, our $R^{**} - R^{\$*}$ calculation suggests convenience yields are around 40bps.

All this suggests 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 (2021), tend to produce much smaller convenience yields of around 40 basis points, in line with our estimates. 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. We agree that

there is a convenience yield, but our evidence questions whether it applies differentially.

5 Conclusion

Foreigners' U.S. Treasury portfolios figure prominently in theories such as the convenience yield. But in most papers in this literature foreign investors' behavior - the nature and evolution of their Treasury portfolios - is inferred from aggregate statistics that are not always internally consistent. We instead 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 and have higher Sharpe ratios than U.S. investors. 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. Our results are consistent with all investors placing the same convenience yield on Treasuries, suggest that going forward the convenience yield literature should not rely on a notion of foreign underperformance.

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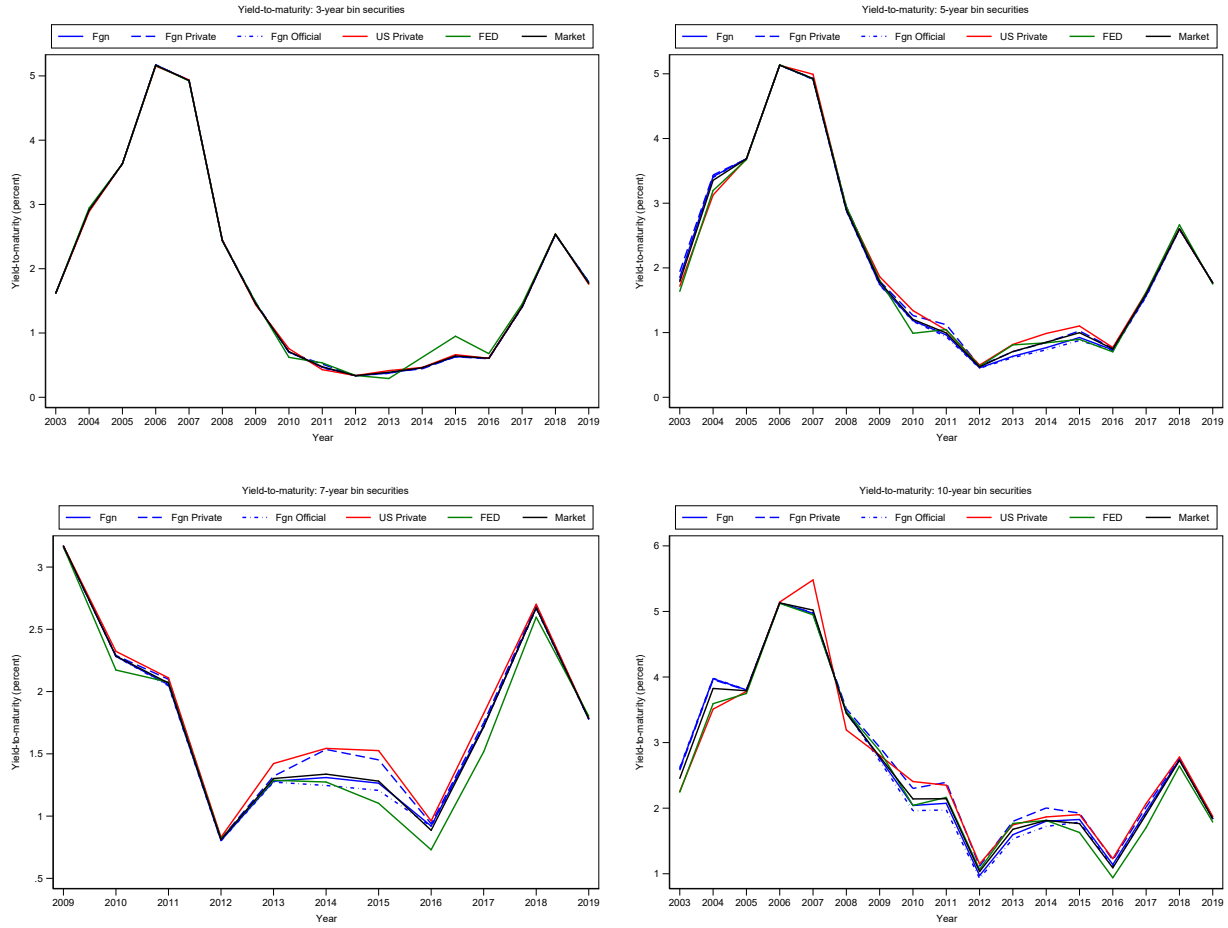
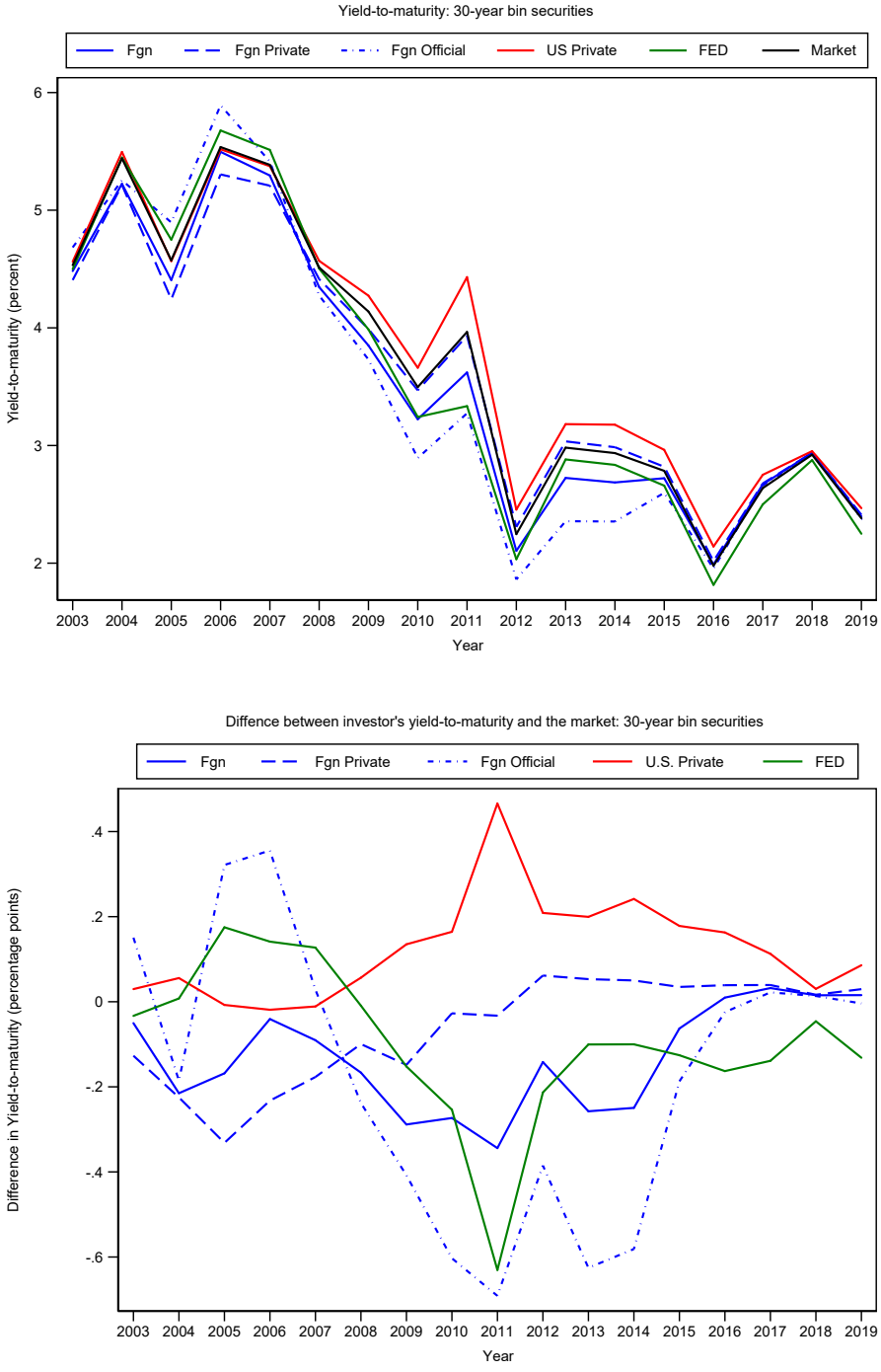
Figure 1: Yield-to-maturity of Treasury holdings per investor type by original maturity



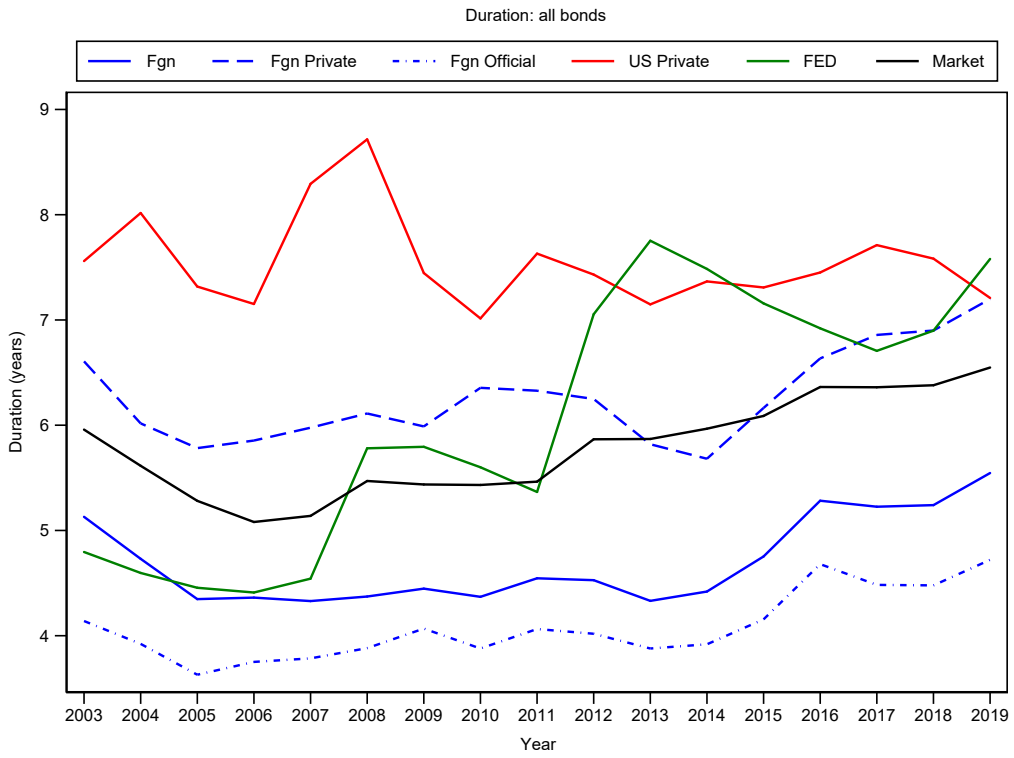
The figure plots weighted averages of yield-to-maturity by investor type and by original maturity (3, 5, 7 and 10 years). Market refers to all outstanding marketable Treasuries as reported by Treasury Direct. Sample excludes floating rate notes (FRN), Treasury inflation protected securities (TIPS), and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

Figure 2: Yield-to-maturity of Treasury holdings per investor type: 20- and 30-year maturity



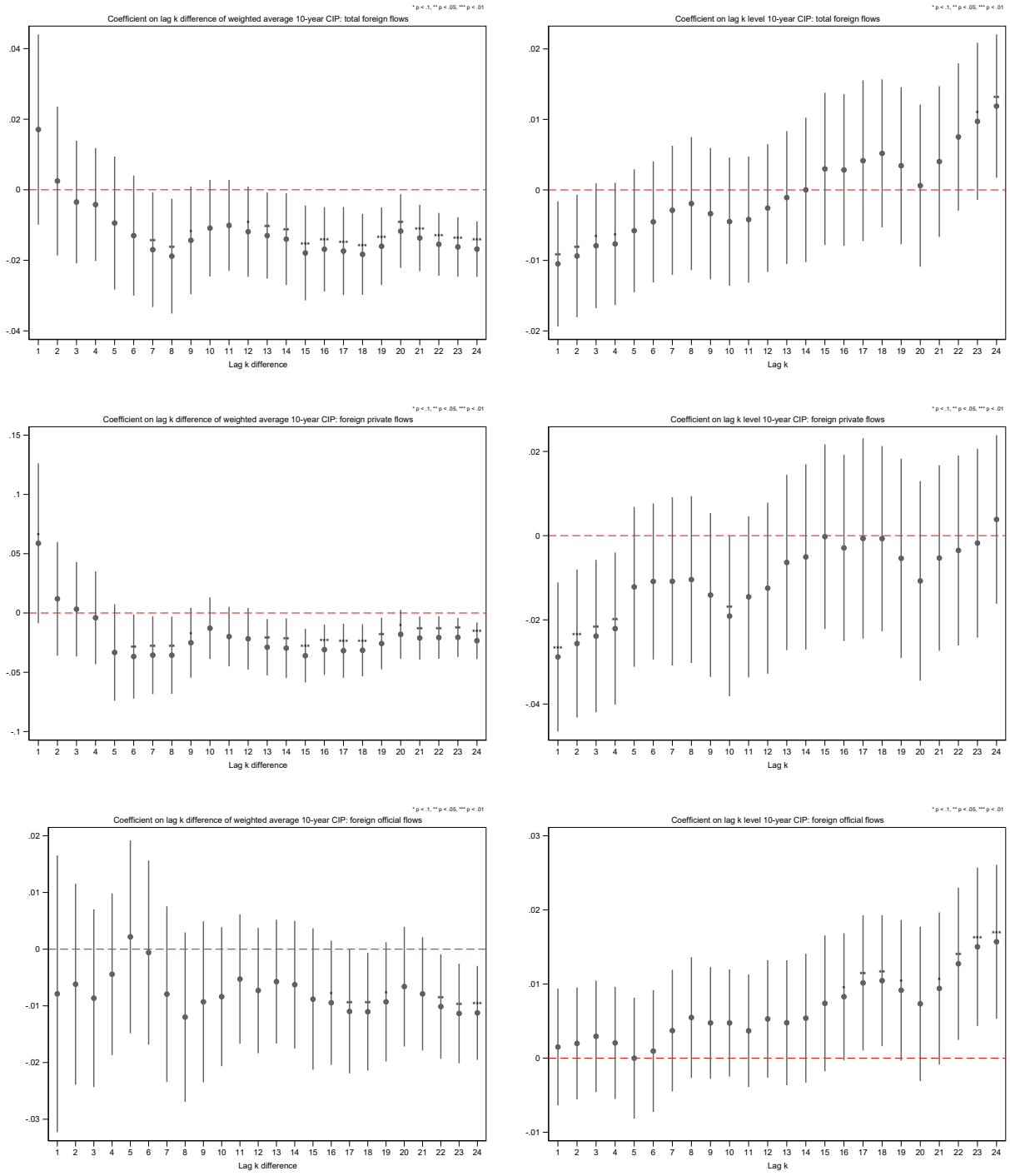
The top figure plots weighted averages of yield-to-maturity by investor type for securities with 20- and 30-year original maturity. The bottom panel plots the difference between these investors' yield-to-maturity and the market. Market refers to all outstanding marketable Treasuries as reported by Treasury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

Figure 3: Duration of Treasury holdings per investor type



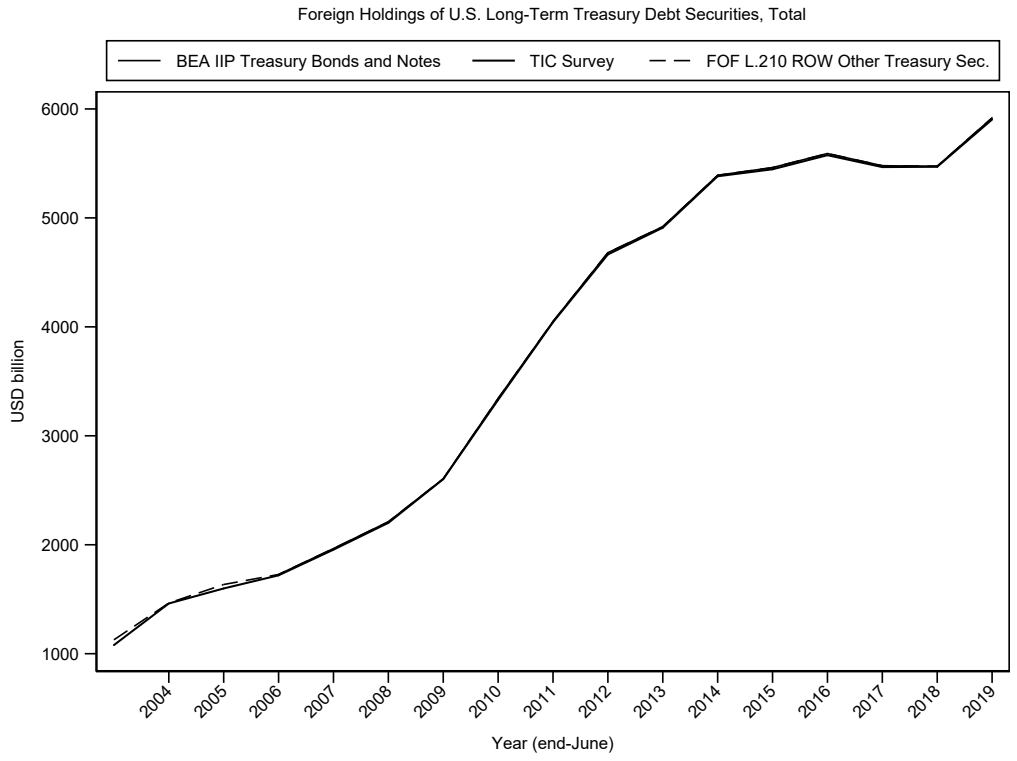
The figure plots weighted averages of duration by investor type. Market refers to all outstanding marketable Treasuries as reported by Treasury Direct. Sample excludes floating rate notes (FRN), Treasury inflation protected securities (TIPS), and securities maturing within one year.

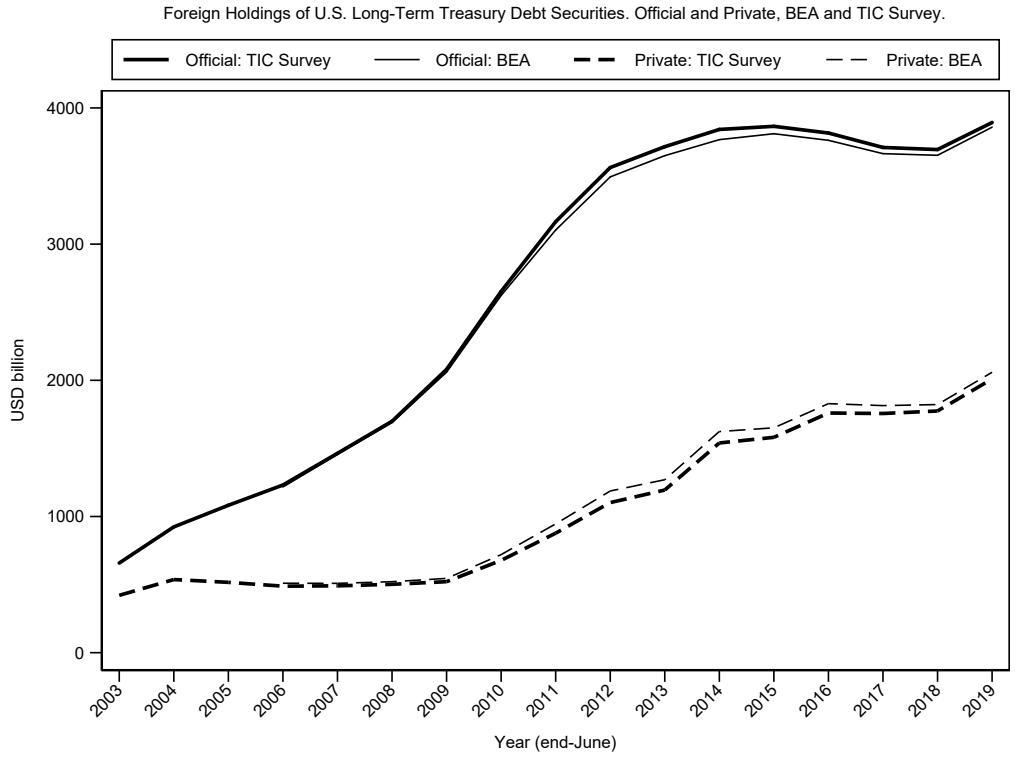
Figure 4: CIP deviations and foreign flows into Treasuries



The left figures plot the coefficients on the lag k difference of the G10 10-year CIP deviation from equation 3 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 4 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.

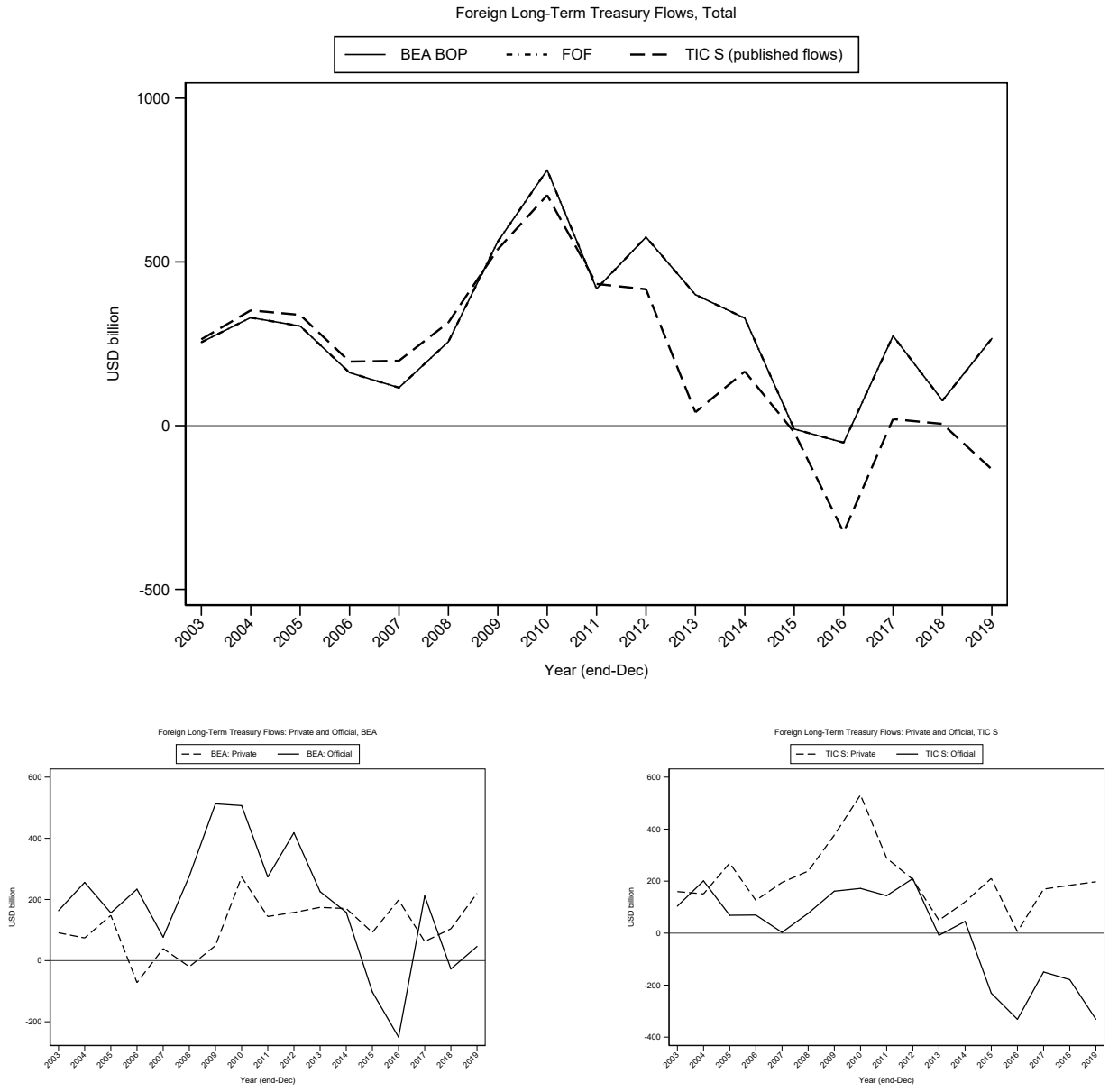
Figure 5: Foreign Holdings of U.S. Long-Term Treasury Securities





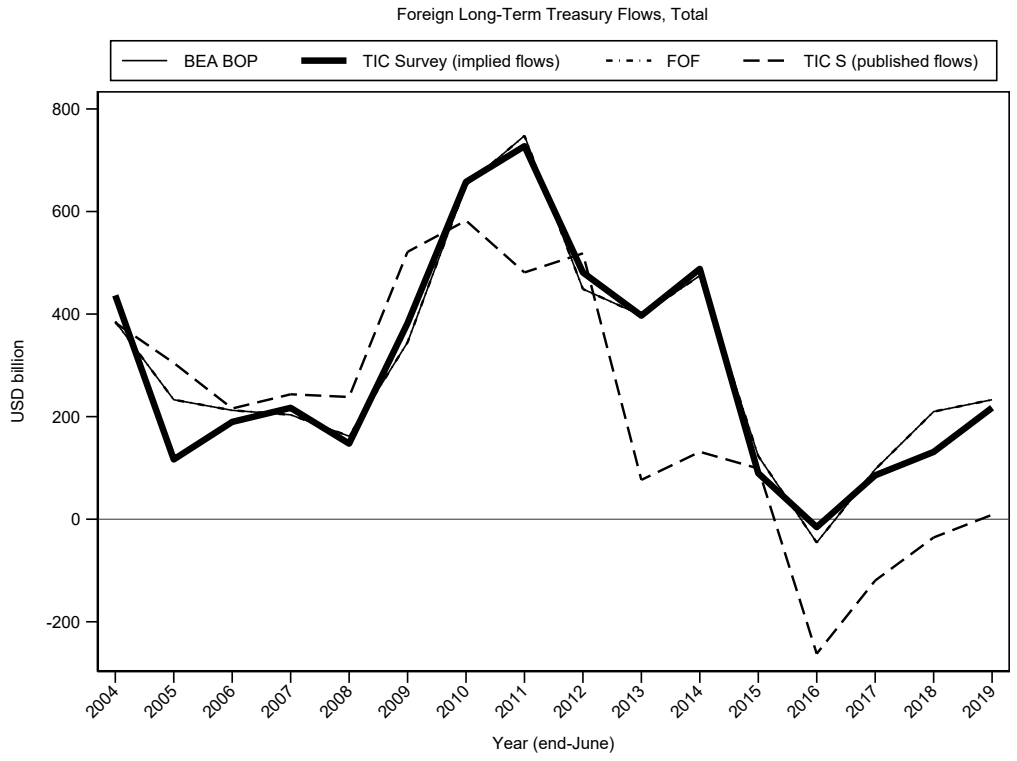
The figure shows, using data from three sources - BEA, TIC surveys, and FOF - the evolution of foreigners' holdings of U.S. Treasury bonds and notes (annual, in billions of U.S. dollars). The lower graph shows foreign private and foreign official holdings (a split that is no longer available in FOF data).

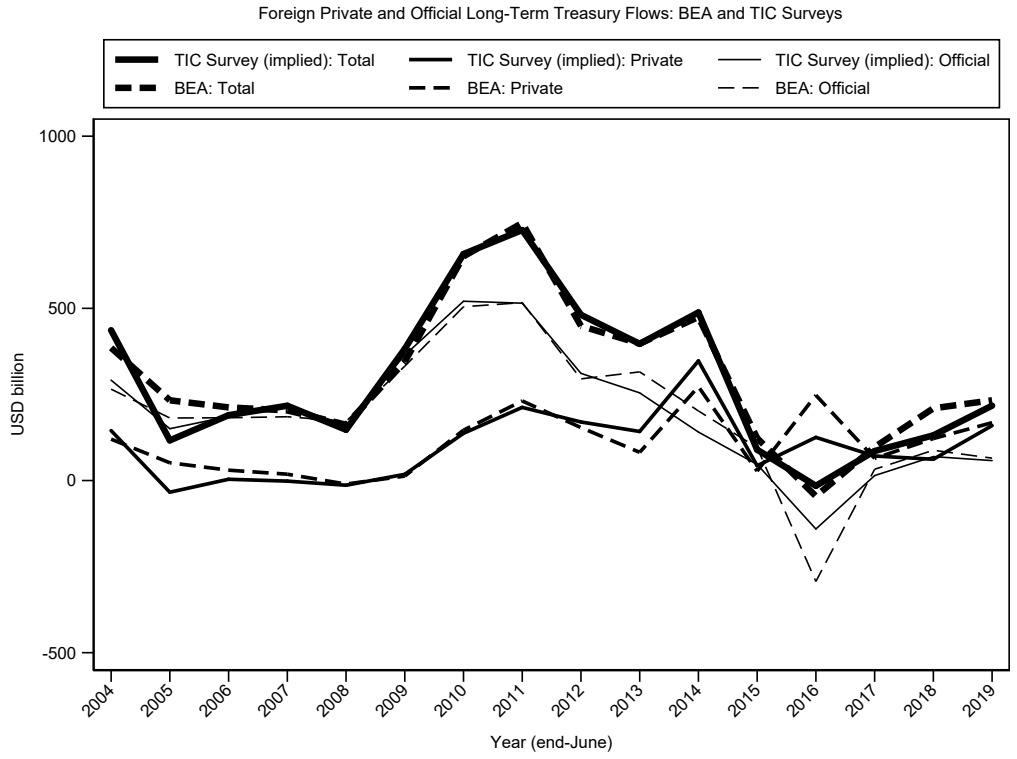
Figure 6: Foreigners' Net Purchases of U.S. Long-Term Treasury Securities



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).

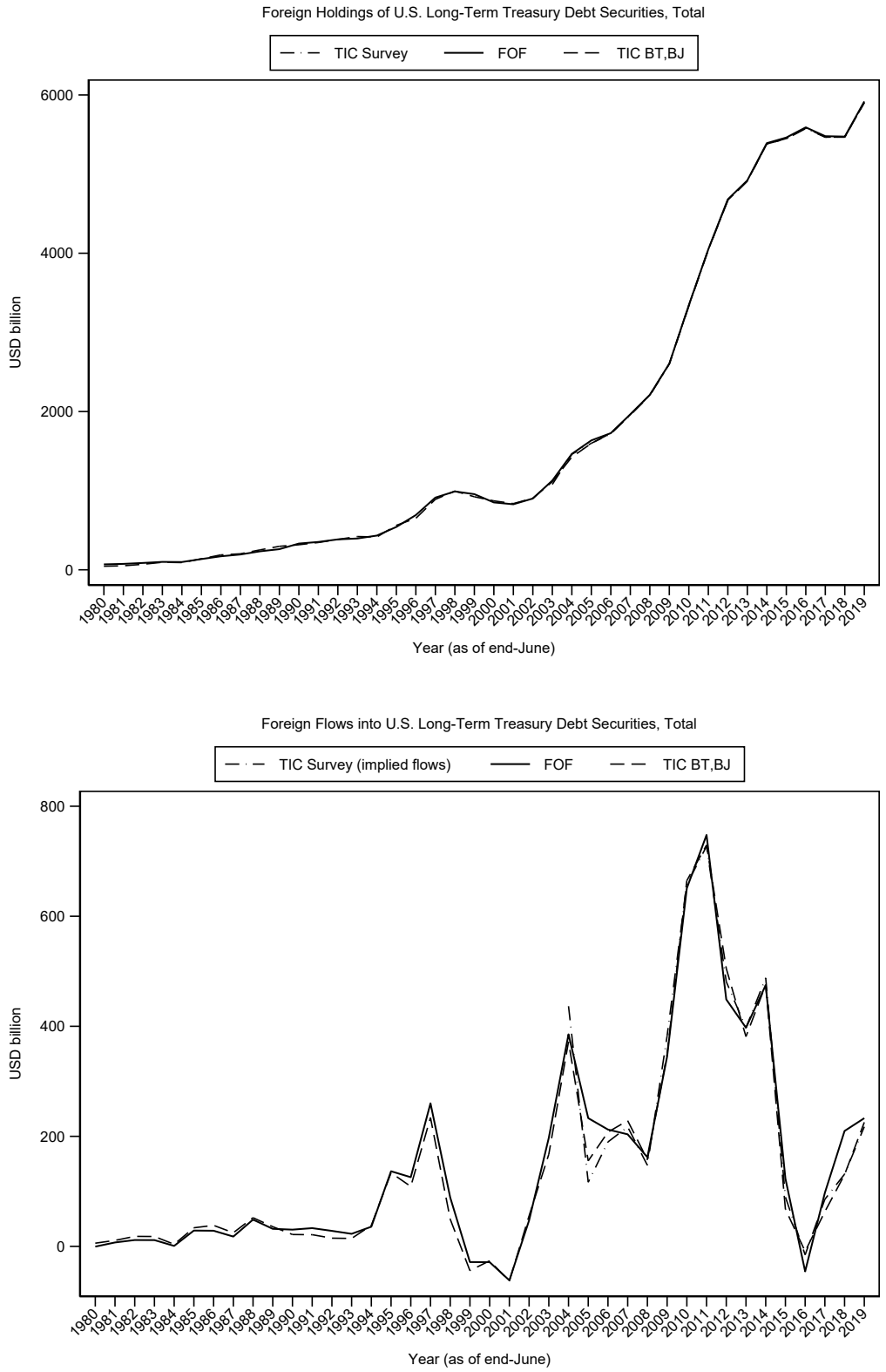
Figure 7: Foreigners' Net Purchases of U.S. Long-Term Treasury Securities





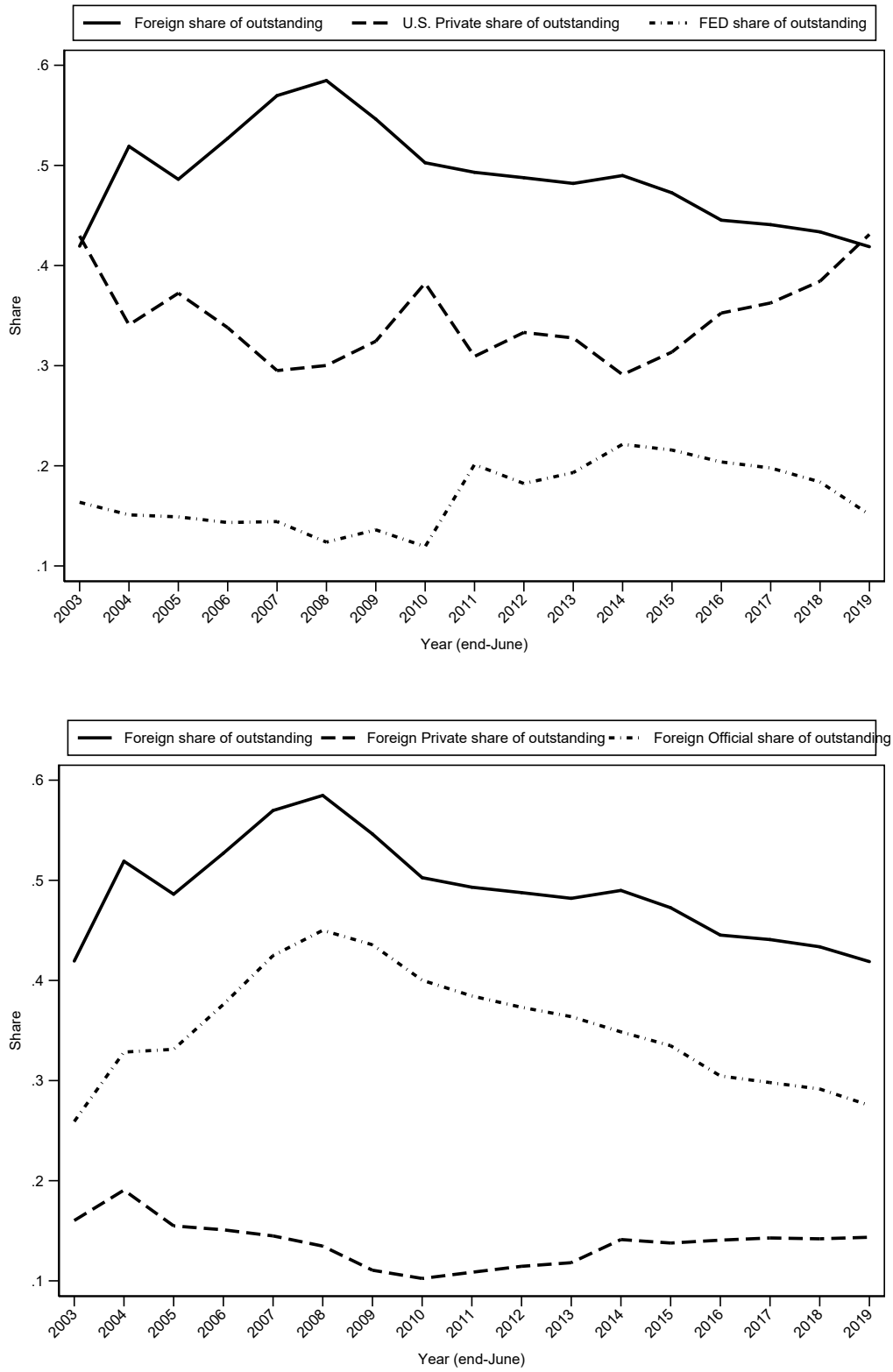
The figure shows, using data from four sources - BEA, TIC annual surveys, TIC S, and FOF - the evolution of foreign flows into U.S. Treasury bonds and notes (annual end-June to end-June, in billions of U.S. dollars). The lower graph shows foreign private and foreign official flows (a split that is no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

Figure 8: Foreigners' Holdings and Net Purchases of U.S. Long-Term Treasury Securities



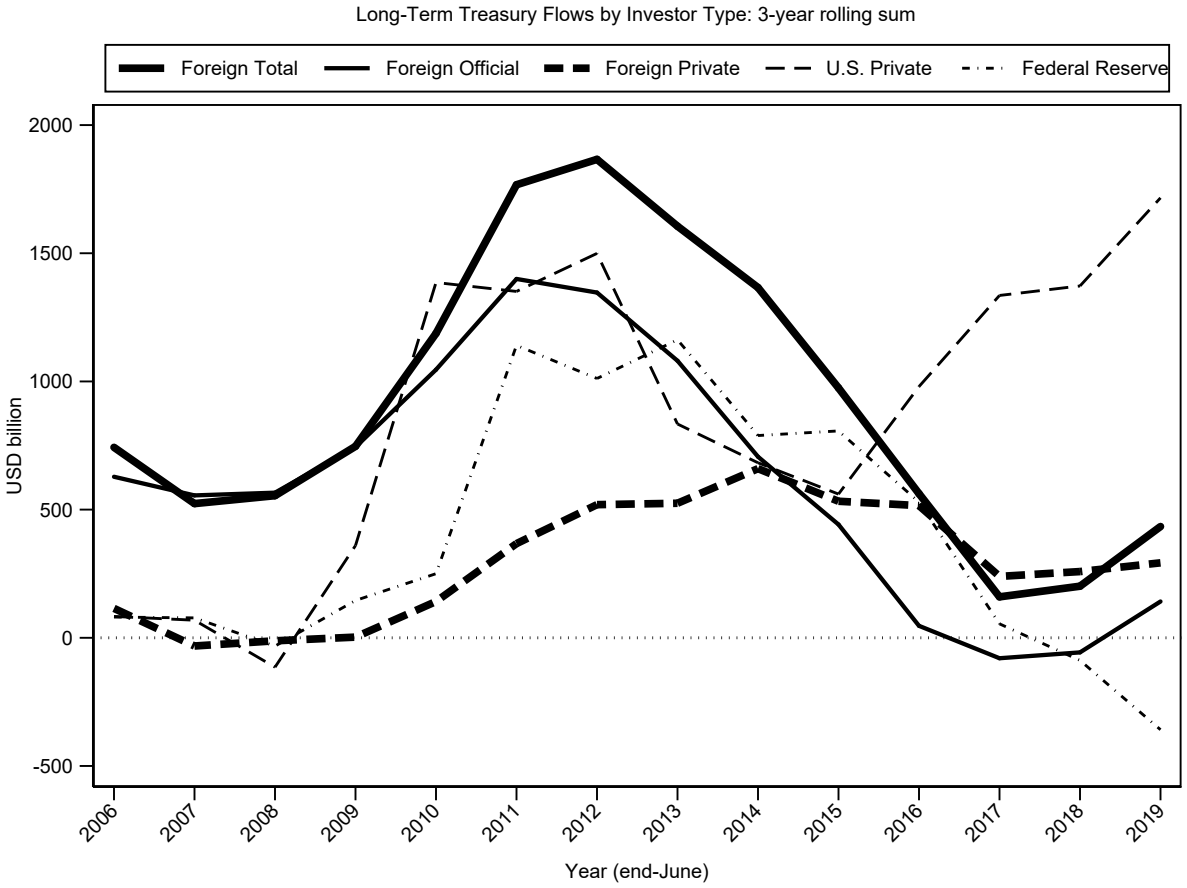
The figure shows, using data from three sources - FOF, TIC annual surveys, and TIC BTBJ - the evolution of foreign holdings of and flows into U.S. Treasury bonds and notes (annual end-June to end-June, in billions of U.S. dollars).

Figure 9: U.S. Treasury Holdings: Foreign (Private and Official), Fed and U.S. Private



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

Figure 10: U.S. Treasury Flows: Foreign (Private and Official), Fed and U.S. Private



The figure shows net purchases (annual end-June to end-June, in billions of U.S. dollars) of Treasuries by foreigners (total, foreign private and foreign official), private U.S. investors, and the Fed.

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
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)		
Federal Reserve	3.70	3.70	3.70
	(0.94)		
U.S. Private	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. private portfolio.

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

	Foreign Private	Foreign Official	Foreign Total	U.S. Private	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: **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 4: **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			

Table 5: Implied Returns on U.S. Treasury Purchases, in percent

Data source	1980q1-2019q2 FOF mv (1)	1980q1-2019q2 BTBJ mv (2)	1986q1-2019q2 BTBJ mv (3)	2003q2-2019q2 TIC Survey mv & face value (4)	2003q2-2019q2 TIC Survey mv (5)	2003q2-2019q2 BTBJ mv (6)
Index RoR (ICE BofAML)	7.24	7.24	6.09	3.56	3.56	3.66
IRR						
Market	5.98	5.98	5.28	3.15	3.15	3.14
Fed	5.49	5.49	4.94	3.60	3.92	3.91
Float (Mkt-Fed)	6.07	6.07	5.35	3.08	3.02	2.96
Foreign Investors	4.27	4.97	4.68	3.14	3.22	3.24
Official		4.85	4.52	3.21	3.29	3.34
Private		5.22	5.01	2.98	3.05	3.02
U.S. Private	7.59	7.00	6.02	2.45	2.61	2.58
Gap=Index (RoR) - Foreign	2.97	2.27	1.41	0.42	0.34	0.42
Gap=Market (IRR) - Foreign	1.71	1.01	0.60	0.01	-0.07	-0.10

The table shows, for three sample periods that end in 2019 and start in 1980, 1986 and 2003, two types of returns: Index RoR, which is the geometric average of returns using a Treasury index, and the implied rate of return (IRR) based on positions and flows. See text for details. Column (1) shows IRR using only FOF data. Columns (2)-(3) show IRR using FOF data for market, Fed, and float and BTBJ data for foreign investors' positions and flows. Columns (4)-(6) show our results for 2003q2-2019q2, when TIC survey (SHL) data became available. These annual surveys are as of end-June of each year. The IRR calculations use these annual positions and flows; the index RoR is also based on annual June through June returns. In column (4) we use the market value of the positions as initial investment and final payout, while for the rest of the sample the coupon is applied to the face value of the positions. In column (5) we use only the market value of the positions. For comparison, in column (6) we use quarterly BTBJ data to calculate the IRR and quarterly index data to calculate the Index RoR. All rates are annualized. Our Index RoR calculations use the ICE BoA Merrill Lynch Treasury index; RoR are similar if we use the Barclays Treasury index (see Table 6 returns series comparisons).

Table 6: Index returns on U.S. Treasury and foreign government securities, in percent

	U.S. Treasury			Foreign Government securities
	Barclays1	Barclays2	ICE BofAML	Global exU.S. hedged
	(1)	(2)	(3)	(4)
1980q1-2019q2	10.18	7.22	7.24	...
1980q1-1985q4	29.13	13.91	13.91	...
1986q1-2019q2	7.10	6.07	6.09	6.49
2003q2-2019q2	3.82	3.61	3.66	4.38

The table shows, for four sample periods, the geometric average of returns on U.S. Treasury and foreign government securities using Barclays and ICE BofAML indices. Barclays1 in column (1) is the Barclays U.S. Treasury index as used in Krishnamurthy and Lustig (2019) and Jiang, Krishnamurthy and Lustig (2021). Barclays2 in column (2) is the Barclays U.S. Treasury index downloaded on July 7, 2021 through Bloomberg. ICE BofAML U.S. Treasury index: G0Q0; ICE BofAML Global Government exU.S index: N0G1. All indices exclude short-term securities. All returns are annualized.