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International capital flows and U.S. interest rates

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ABSTRACT

Foreign purchases of U.S. government bonds have an economically large and statistically significant impact on long-term interest rates. While the dramatic reductions in both long-term inflation expectations and the volatility of long rates contributed much to the decline of long rates in the 1990s, more recently foreign flows have become important. Controlling for various factors, we estimate that absent the substantial foreign inflows into U.S. government bonds the 10-year Treasury yield would be 80 basis points higher. Our results are robust to a number of alternative specifications.

1. Introduction

By now the discussion about whether U.S. long-term interest rates have been substantially lower than suggested by economic fundamentals is well known. This phenomenon, labeled a conundrum by then Fed Chairman Greenspan, has led to much discussion about possible causes of the deviation of actual long rates from their predicted levels (e.g., Berner and Fantuzzi, 2006; Economist, 2005a,b).[1] One possible cause of the conundrum was downplayed by Greenspan himself when he opined that the foreign buying of U.S. bonds probably depressed U.S. long rates by "less than 50 basis points".[2]

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[1] Some argue that the behavior of long-term rates has not been surprising. See, for example, Bandholz et al. (2007), Fels and Pradhan (2006), and Thornton (2007). On this topic, see also Frey and Moët (2005).

[2] Response to Senator Shelby, Senate Banking Committee hearing, July 25 2005.

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In this paper we use a simple empirical model along with novel (and, we argue, more informative) measures of foreign flows to provide an assessment of the influence of international capital flows on long-term U.S. interest rates. We make two contributions to the literature. First, we show that foreign flows have had a statistically and economically significant impact on U.S. long-term rates. Our second contribution is ancillary but nevertheless important. Although the use of capital flows data has sky-rocketed in recent years in both practitioner and academic circles, there is considerable confusion about such data. We address this by first highlighting some less-than-desirable features of reported capital flows data and then presenting an alternative "benchmark-consistent" capital flows measure that addresses known limitations in reported capital flows.

Using our benchmark-consistent flows, for a monthly sample spanning January 1984 to May 2005 we find that foreign inflows into U.S. bonds reduce the 10-year Treasury yield by an economically and statistically significant amount.[3] The model illustrates that the most important factor contributing to the decline in nominal long-term interest rates from 9 percent in 1987 to roughly 5 percent by the end of the 1990s are reductions in both long-term inflation expectations and the volatility of long rates.[4] But international capital flows also have a significant impact on long rates. For example, if foreign governments did not accumulate U.S. government bonds over the twelve months ending May 2005, our model suggests that the 10-year Treasury yield would have been roughly 80 basis points higher; if instead they reduced holdings by the same magnitude of their accumulation, the impact would be doubled. Further analysis indicates that much of this impact comes directly from East Asian sources.

The implications of our results are clear. The most obvious is that foreign inflows, by depressing long-term U.S. rates, have spurred U.S. economic activity. In a world of substantial inflows into U.S. bonds, Fed policy is less restrictive than otherwise. At a sectoral level, one expects the most interest-rate sensitive sectors, such as housing, to bear the bulk of this effect. Indeed, we show (not surprisingly) that U.S. mortgage rates are also depressed by the foreign inflows. A related but less obvious implication is that our results are consistent with the notion that foreign flows are behind some of the flattening of the yield curve. We estimate models for a variety of U.S. interest rates – shorter term Treasury yields (2 years), high and lower quality corporate debt (Aaa and Baa), and long-term fixed and short-term adjustable mortgage rates. The impact of foreign inflows differs across these instruments, but it is always statistically significant and often economically large. The impact on corporate bond rates and long-term (30 years) fixed mortgage rates is very similar to that on the 10-year Treasury yield, but we find that the 2-year rate is less affected by foreign flows, perhaps because it is a deep market that is more closely linked to short rates. The differential effect on the 2- and 10-year Treasury yields implies that in 2004 and 2005 foreign flows flattened the yield curve by about 50 basis points.

Our results are robust to alternative specifications. To alleviate potential concerns about structural breaks, we re-estimate starting the sample at two significant events, when Greenspan became Chairman in August 1987 and when the Fed began announcing the target federal funds rate in February 1994. We impose a structure that is consistent with the potential non-stationarity of nominal rates, but to further alleviate stationarity concerns we also model real rates. Perhaps more convincingly, for robustness we also estimate an error correction model following Bandholz et al. (2007). None of the robustness checks alters our main finding that foreign flows impact long-term U.S. interest rates.

Our work is related to a number of strands of the literature. Bernanke et al. (2004), perhaps the closest precursor to our work, utilizes an affine term structure model to identify (domestic) macro-economic factors that impact yields and, separately, includes a high frequency study of the short-run impact of announced Japanese intervention.[5] Our work can be seen as encompassing certain aspects of the notion of a global saving glut. Bernanke (2005) argues that two important factors in the global saving glut story are the sharp reserve accumulation by developing countries and the surge in revenues of oil producers. Both mechanisms are incorporated directly in our preferred measure of foreign official

[3] Our sample begins in 1984 because we do not have some of the control variables prior to that date.

[4] The reductions in volatility and inflation expectations could owe to improved credibility of Fed policy, consistent with the view Poole (2005), or to a relative absence of adverse shocks.

[5] The simplicity of our model does not appear to overly handicap our analysis, as the fit of our model (excluding flows) is comparable to that of the affine term structure model of Bernanke et al. (2004).

inflows, and our analysis suggests that East Asian accumulation is responsible for about two-thirds of our estimated impact. To the extent that many oil producers and some developing countries shun U.S. intermediaries, our benchmark-consistent capital flows series is necessary to capture these flows. Finally, our work is also related but distinctly separate from the recent literature on the impact of order flow on exchange rates (Evans, 2002; Evans and Lyons, 2002) and Treasury yields (Brandt and Kavajecz, 2004; Green, 2004).[6]

The paper is structured as follows. In the next section, we discuss problems with reported capital flows data and then show how to restate the data to bring them in line with higher quality (but infrequent) benchmark surveys. In Section 3, we present our main regression results with foreign flows, as well as various robustness checks. Section 4 concludes.

2. U.S. data on international capital flows

There are many interrelated sources of data on U.S. capital flows. In this section we discuss weekly data from Federal Reserve Bank of New York (FRBNY), monthly data from the Treasury International Capital Reporting System (TIC), and monthly flows implied from infrequent benchmark surveys of positions (which we call benchmark-consistent flows). The TIC data are more comprehensive than the FRBNY data. However, because of limitations of the monthly TIC data, discussed below, our preferred measure utilizes the benchmark-consistent flows – the restated flows that incorporate information from benchmark surveys.

2.1. Attributes of officially reported data

Past work on international capital flows and U.S. interest rates, such as Sack (2004), which formed the basis for Greenspan's remark that capital flows likely had only a small impact on U.S. long-term rates, utilized a *partial measure* of flows from the FRBNY. The most timely source of U.S. data on capital flows is the weekly H.4.1 release that includes information on U.S. government securities held in custody at the FRBNY on behalf of foreign *official* institutions (central banks and finance ministries). The weekly FRBNY custodial data are easily obtained[7] and of high quality; mistakes in FRBNY data are similar to a bank recording the wrong amount for an account balance, infrequent and likely quickly corrected. But the FRBNY is just one of many custodians that foreign governments might use. For *reported* U.S. capital flows data, FRBNY is the U.S. custodian of choice for many of the world's central banks and finance ministries; at the end of June 2003, 88 percent of *reported* foreign official holdings of long-term Treasury securities were held in custody at the FRBNY.[8] However, some foreign governments, notably Middle East oil exporters but also others, avoid the FRBNY and thus this source is best described as only partial.

A much broader source than the FRBNY is the Treasury International Capital Reporting System (TIC), of which the FRBNY data is a subset. The TIC system, the official source of U.S. capital flows data, reports monthly data (with a six-week lag) on foreigners' purchases and sales of all types of long-term securities (equities as well as corporate, agency, and Treasury bonds).[9]

The TIC system has two deficiencies. The first deficiency is that it cannot differentiate between foreign officials and other investors when the transaction goes through a third-country intermediary.

[6] Order flow research, which examines the impact of flows on prices, is distinct from our work because it identifies flows that are driven by private information. We cannot make such statements about our flows data, nor can most researchers; even the recent Evans and Lyons (2005) cannot identify true order flow.

[7] A memo item at the bottom of Table 1 of the H.4.1 release (www.federalreserve.gov/releases/h41/) shows foreign official holdings at the FRBNY. The Treasury and FRBNY data are not directly comparable for a number of reasons; see question C10 on Treasury's FAQ site (www.treas.gov/tic/faq1.html).

[8] From Table 10 of Treasury et al. (2004) and the historical Major Foreign Holders table (available at www.treas.gov/tic/mfhhis01.txt), foreign official holdings at all U.S. custodians totaled $864 billion ($653 billion in long-term Treasury securities and another $211 billion in short-term Treasury bills), of which $757 billion were held in custody at FRBNY.

[9] The TIC data also include data on short-term instruments and on U.S. investors trading in foreign securities. We do not focus on short-term flows in this paper.

The TIC system asks data reporters to provide information on the transactions of all foreigners and, where possible, the subset that can be attributed to foreign official entities. Just as FRBNY data are undermined by foreign governments avoiding it as a custodian, the split between foreign official and other foreign investors in the TIC data is blurred by the practice of some foreign governments to use third-country intermediaries. Indeed, there is increasing evidence that some governments that are known to accumulate vast amounts of U.S. Treasuries (such as oil exporters) are doing so through foreign intermediaries. In this case the TIC system may well capture the flow, but will not attribute it to a foreign official investor or even the particular country (if, as is likely, it is executed through an offshore intermediary). Moreover, TIC-recorded foreign *official* inflows represent only a lower bound because some prominent foreign governments purchase U.S. securities through offshore centers.[10] The second deficiency is that TIC-reported flows greatly overestimate foreign purchases of certain types of U.S. government bonds. Specifically, the TIC system records far too many inflows into U.S. agency bonds; we show that in the one-year period from mid-2001 to mid-2002, capital inflows into U.S. agency bonds were *overstated* by $158 billion.[11]

Comprehensive benchmark survey data of foreign holdings are also undermined by the use of third-country custodians. That said, the benchmark data are the most accurate and can be used to make an important point: of foreigners' holdings of U.S. Treasury and agency debt securities, the majority is held by foreign officials. Specifically, lower bound estimates (lower bound because some foreign official holdings will show up as private holdings) indicate that foreign officials hold 63 and 35 percent, respectively, of all foreigners' holdings of Treasury and agency bonds.[12] In contrast, foreign officials are not keen on corporate bonds, holding only 3 percent of the total. One way of thinking about this is that (at least through 2005) governments were not in the business of investing in, or lending to, foreign corporations. Because much of reported foreigners' holdings of U.S. Treasury and agency bonds are held by foreign officials and the TIC system is not always able to accurately differentiate between foreign officials and other foreign investors (such as pension funds, oil stabilization funds, insurance companies, and others) when the trade is made through a third-country intermediary, we utilize overall TIC foreign flows into Treasury and agency bonds in constructing our preferred measure of foreign official accumulation.

The benchmark surveys can also be used to address questions about the overall accuracy of TIC data (Warnock and Cleaver, 2003). While we have no direct way of knowing whether the TIC capital flows data are accurate, because benchmark surveys of capital *flows* do not exist, the high quality security-level benchmark surveys of foreigners' *holdings* of U.S. securities – surveys that recently have been conducted annually – can be used to gauge whether recorded capital flows data are reasonably accurate. Specifically, one can form flows-based *holdings* estimates and compare them with known *holdings* from the benchmark surveys. The comparison is not perfect, because unknown valuation adjustments are incorporated into the marked-to-market positions data, but large discrepancies between holdings given by the comprehensive benchmark surveys and holdings implied from capital flows data would indicate a problem with the flows data.

Fig. 1 shows flows-based holdings estimates (the solid lines) and benchmark amounts (the dots) for foreigners' positions in Treasury and agency bonds; complete details on the methodology for forming the flows-based holdings estimates are presented below. For Treasury bonds, reported TIC flows appear to have run a bit high in the late 1990s; the March 2000 estimate of $1,063 billion is almost $200 billion higher than the amount collected through the benchmark survey. Since then, however, there is no evidence that TIC flows for Treasury bonds are inaccurate, as estimated holdings are right in line with benchmark amounts. Given that, and because it is not entirely clear whether the miss in 2000 owed to errors in TIC data or errors in the benchmark survey, we are comfortable using TIC-reported data for Treasury bonds. Agency bonds are another story: the TIC system consistently overestimates foreigners'

[10] Roach (2005) states that U.S. data do not capture any of the roughly $700 billion in oil proceeds that may have been recycled into U.S. Treasuries in 2005. See also Economist (2005b).

[11] Given questions about whether long-term inflows can cover the U.S. current account deficit (Feldstein, 2006), a $158 billion overstatement in a 12-month period is both sizeable and important.

[12] Treasury Department et al. (2005, Table 6).

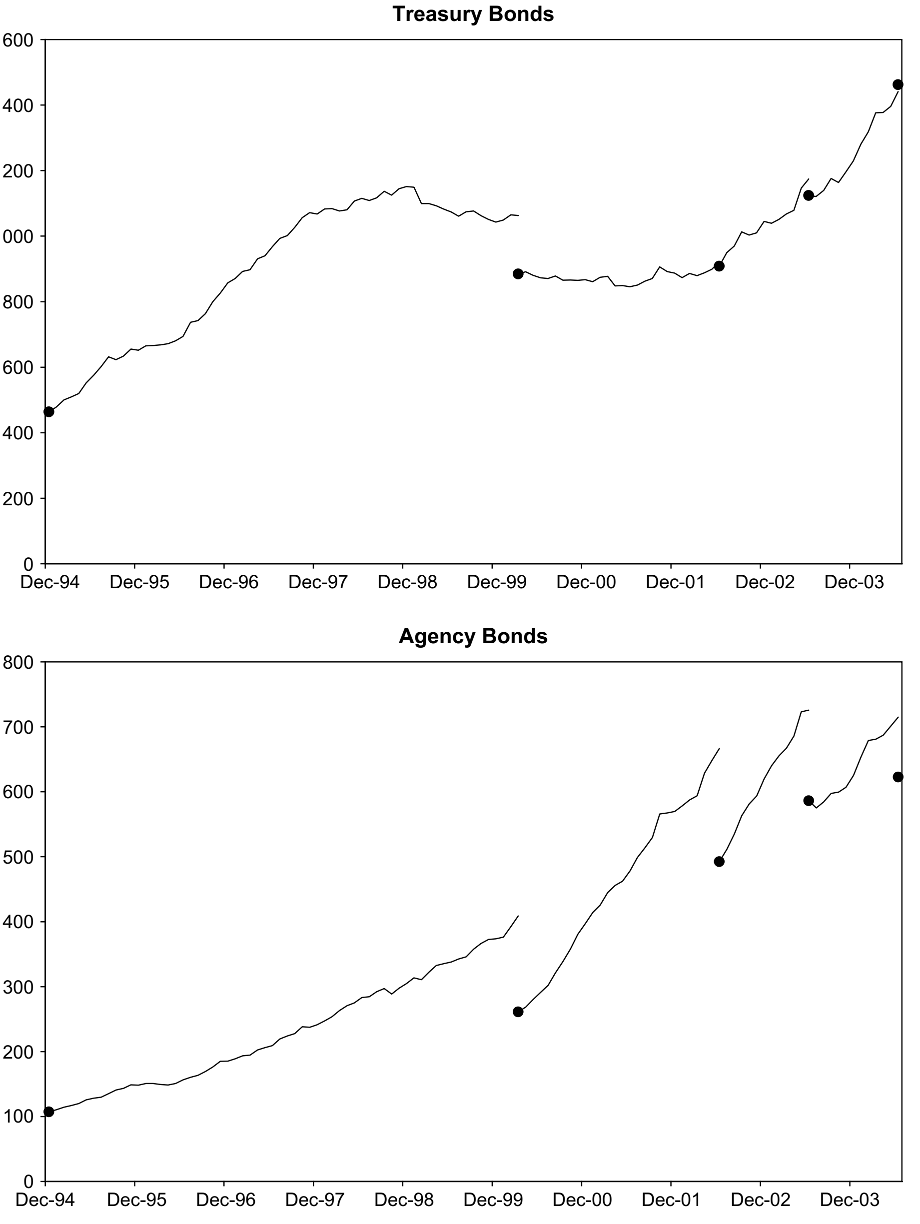

Fig. 1. TIC-based Estimates of Foreign Positions in U.S. Bonds. TIC-based estimates start from benchmark survey amounts, shown by the large dots, and are formed by applying equation (1). While unknowable valuation adjustments are also included in these estimates, major discrepancies in TIC-based estimates and the benchmark surveys are indicative of problems with the TIC data. All data are in billions of dollars.

purchases of agency bonds, suggesting that for these securities an adjustment to TIC-reported flows is necessary.[13]

2.2. Forming benchmark-consistent flows

The discrepancy between flows implied from high-quality benchmark surveys and TIC-reported flows makes it difficult for market participants to interpret and use the TIC transactions data. We present a solution that utilizes the benchmark survey data to guide a restatement of monthly TIC flows. The resulting series, which we call benchmark-consistent flows, will be quite similar to reported TIC flows when TIC flows are in line with the surveys. But where there is a wide discrepancy between TIC flows and benchmark surveys – as with agency bonds – our benchmark-consistent flows will differ substantially from reported TIC flows.

To create benchmark-consistent capital *flows* data, we restate monthly TIC flows so that flows-based *holdings* estimates are consistent with *holdings* reported in periodic benchmark surveys. We require the following data. *Bilateral capital flows*, or foreigners' transactions in U.S. securities, are reported monthly to the TIC System, mainly by brokers and dealers. For U.S. long-term debt securities (with original maturity greater than one year), these mandatory reports contain information on gross purchases and gross sales (at market value) and the country of the foreign counterparty to the transaction. The TIC data are available at www.treas.gov/tic. Data on foreign holdings of U.S. securities, available at www.treas.gov/fpis, are collected in detailed but infrequent security-level *benchmark liabilities surveys* conducted in December of 1978, 1984, 1989, and 1994; March 2000; and June of 2002, 2003, and 2004.[14] Reporting to the surveys is mandatory, with penalties for noncompliance, and the data received are subjected to extensive analysis and editing. For liabilities surveys (of foreign holdings of U.S. securities), the reporters consist primarily of large custodians (banks and brokers–dealers). U.S. firms that issue securities are also included in the survey, but they typically have little information about the actual owners of their securities because U.S. securities are typically registered on their books in "street name" – that is, in the name of the custodian, not of the ultimate investor. *Valuation adjustments* are from the Lehman Brothers US Treasury Index and the Lehman Brothers US Agency Index. The TIC data are reported gross at cost including commissions and taxes, so to compute the value of securities bought or sold, an adjustment for *transaction costs* must be made. For round-trip transaction costs in U.S. debt securities, we rely on estimates of bid-ask spreads provided by market participants of 5 basis points on US Treasury debt and 10 basis points on US agency debt.

To form benchmark-consistent capital flows data, we first form monthly benchmark-consistent holdings. The restated flows consistent with those holdings estimates are our benchmark-consistent flows. We form separate estimates for agency and Treasury bonds. All that follows is for a particular type i of long-term debt security ($i = agency, Treasury$); we omit the subscript i in the equations below.

We begin by forming naive baseline estimates. End-of-month holdings are formed by adjusting the previous month's holdings for estimated price changes and adding the current month's (transaction cost-adjusted) net purchases. Specifically, we use the following formula to form naive estimates of foreign investors' holdings of U.S. debt securities at the end of period t:

$$nh_t = nh_{t-1}(1 + r_t) + gp_t(1 - tc) - gs_t(1 + tc) \quad (1)$$

where nh_t is naive estimates of foreign holdings of U.S. bonds at the end of month t, r_t is returns from period $t-1$ to t, computed from appropriate price indices, gp_t is foreigners' gross purchases of U.S. bonds during month t, gs_t is foreigners' gross sales of U.S. bonds during month t, and tc a constant adjustment factor for transaction costs.

[13] This owes to an inability of the TIC system to cost-effectively collect data on the periodic principal payments on mortgage-backed securities – which should be recorded as capital outflows. The TIC web site (www.treas.gov/tic/absprin.html) describes the issue and provides adjustments; however, those adjustments appear to be far too small to eliminate the discrepancy.

[14] Details of the 2004 liabilities survey, including findings and methodology, are discussed in Treasury Department et al. (2005). Griever et al. (2001) and Bertaut et al. (2006) are primers on the surveys. The recent annual surveys are "mini" surveys that serve to supplement the quinquennial full benchmarks.

We then combine the naive baseline estimates with holdings from the infrequent benchmark surveys (conducted at time T) to form benchmark-consistent holdings estimates. For example, to form estimates for the January 1995 – March 2000 inter-survey period, we start from the December 1994 benchmark survey amount and apply equation (1) to form estimates to March 2000. Doing so results in a naive estimate of holdings as of March 2000 (nh_T) that differs from holdings as given by the benchmark survey (bh_T) by an amount, gap_T:

$$gap_T = bh_T - nh_T. \tag{2}$$

One possible cause for the gap is errors in the capital flows data. Assuming that such errors are larger in months with greater trading activity, we add to each inter-survey month an amount that is a function of the gap and the proportion of inter-survey trading activity that occurred in that month. That is, we add to month t's net purchases of U.S. bonds an adjustment given by:

$$adj_t = gap_T * adjfactor * \frac{gp_t + gs_t}{\sum_{k=1}^{T} gp_k + gs_k} \tag{3}$$

where periods 1 and T span the entire inter-survey period. For each inter-survey period, everything on the right side of (3) is given except *adjfactor*, which we choose to minimize the distance at time T between benchmark holdings and our adjusted holdings estimates:

$$\min|bh_T - h_T| \tag{4}$$

where our adjusted holdings estimates, h_t, evolve according to

$$h_t = h_{t-1}(1 + r_t) + gp_t(1 - tc) - gs_t(1 + tc) + adj_t, \tag{5}$$

and, for all t, we impose a non-negativity constraint on our holdings estimates:

$$h_t \geq 0. \tag{6}$$

Because the adjustment for any period t must be part of the revaluation that produces period $t+1$ holdings (and so on), this is not a simple linear problem and, accordingly, we employ a grid-search method to solve for the adjustment factor. Once the adjustment factor is determined and applied to (3), our benchmark-consistent flows, or net purchases (np_t), are given by

$$np_t = gp_t(1 - tc) - gs_t(1 + tc) + adj_t. \tag{7}$$

Note three features of our adjustment factor. First, *adjfactor* can differ across inter-survey periods. Second, *adjfactor* is constant within an inter-survey period, but the adjustment itself, adj_t, is time-varying. Third, for the period after the last survey we cannot form adjustment factors and so apply *adjfactor* from the previous inter-survey period. To the extent that the relationship between TIC-reported flows and benchmark surveys will change in the future, our estimates that post-date the most recent survey should be considered preliminary.

Because the TIC data overstate foreign flows into U.S. bonds, our adjustments will generally reduce reported flows. This is especially true for agency bonds. For example, in the 12-month period from July 2001 to June 2002, the TIC system reported that foreigners purchased on net \$206 billion in agency bonds, whereas our monthly benchmark-consistent flows totaled only \$68 billion for the same period. In the empirical work that follows, for aggregate flows into U.S. government bonds we utilize benchmark-consistent flows.[15]

[15] Our technique has recently been adopted at the Federal Reserve Board (Bertaut and Tryon, 2007) with only slight modifications. Another source of international flows data is the BEA's quarterly BOP release. For long-term securities, the quarterly BOP data is formed essentially by summing the monthly TIC data. However, BEA adjusts reported TIC data if they deem it warranted. BEA determines whether TIC flows data should be altered by consulting the infrequent benchmark positions data, so their adjustment is similar in spirit to ours. That said, their adjustments are best thought of as partial (Curcuru et al., 2008), so we do not use BEA data here. Benchmark-consistent flows for the components of overall bond inflows are not available prior to 1994, so pre-1994 our preferred measure utilizes reported TIC data.

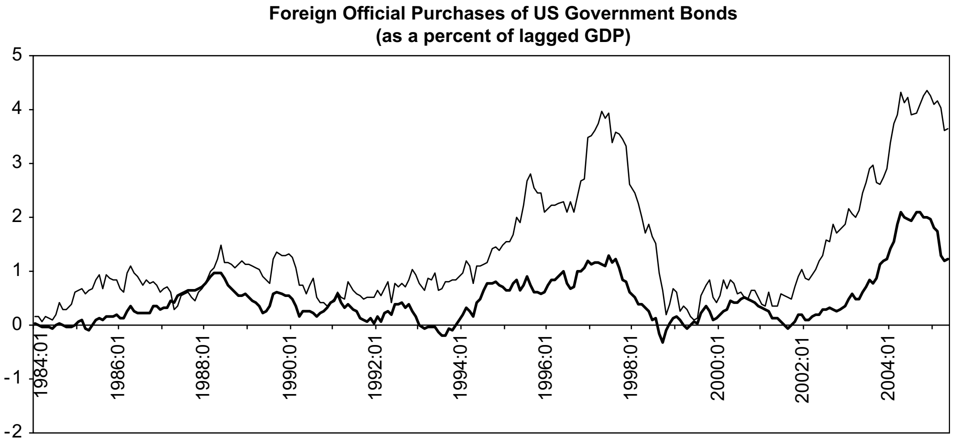

Fig. 2. Foreign Inflows into U.S. Government Bonds. Both variables are 12-month flows scaled by lagged GDP. The thick line represents foreign official flows into U.S. government bonds. The thin line is aggregate foreign flows into U.S. government bonds, based on our benchmark-consistent flows.

3. The impact of foreign flows on U.S. interest rates

In this section we present our primary regression model of the 10-year yield; regressions of other interest rates (short rates, rates on corporate bonds, and mortgage rates); and results from a dynamic model.

3.1. Foreign inflows and long-term treasury yields

To capture any systematic effects of exogenous inflows on Treasury yields, we use (alternately) two measures of capital flows, depicted in Fig. 2. The first measure is benchmark-consistent flows, our adjusted series on total foreign accumulation of U.S. government bonds. The second is the TIC-reported series on foreign official purchases of U.S. government bonds. As discussed above, we consider the benchmark-consistent flows to be the more accurate series and the TIC-reported official flows to be a lower bound.

The basic empirical model is similar but not identical to that in Sack (2004). Because the Treasury yield is a forward-looking asset price, the model relies where possible on variables that encompass forward-looking expectations or at least can be observed in real time. Specifically, we use OLS to estimate the following reduced-form equation to explain the nominal 10-year Treasury yield, $i_{t,10}$, over the period January 1984 – May 2005.

$$\begin{aligned} i_{t,10} = {} & a + b\pi^e_{t+10} + (1-b)i_{t,3m} + c(\pi^e_{t+1} - \pi^e_{t+10}) + d(rp_t) + e\left(y^e_{t+1}\right) + f(deficit_{t-1}) \\ & + g(foreign_t) + \varepsilon_t \end{aligned} \tag{8}$$

where π^e_{t+10} and π^e_{t+1} are 10-year- and 1-year-ahead inflation expectations; $i_{t,3m}$ is the 3-month Eurodollar rate; rp_t is an interest rate risk premium; y^e_{t+1} is expected real GDP growth over the next year; $deficit^e_t$ is the expected structural budget deficit (scaled by lagged GDP); and $foreign_t$ is 12-month foreign flows into U.S. bonds (scaled by lagged GDP). Short-term expectations of future output and inflation are from the Blue Chip survey. Long-term inflation expectations, from the Philadelphia Fed's Survey of Professional Forecasters, are interpolated to the monthly frequency.[16] Current monetary

[16] Ang et al. (2007) show that surveys forecast inflation quite well. Another measure of inflation expectations, TIPS, are not yet usable for time series analysis (Kwan, 2005), but show similar levels as the survey data we use.

policy is measured by the 3-month rate, not the target federal funds rate, because the fed funds rate changes only infrequently. The risk premium, which proxies for interest rate and reinvestment risk, is measured as the volatility of long-term interest rates (calculated as the rolling 36-month standard deviation of changes in long rates). The stance of fiscal policy is a bit trickier to capture. Laubach (2003) utilizes the long-dated budget projections of the Congressional Budget Office (CBO) or Office of Management and Budget (OMB), but these projections are not available to us. Instead, we use as a proxy for the expected deficit a readily available measure, the CBO's series on the *structural* budget deficit, expressed as a percent of lagged GDP, interpolated to the monthly frequency. Our measure has one thing in common with the long-dated projections; being structural, it abstracts from current business cycle conditions.[17]

The *domestic* explanatory variables, intended to provide an effective summary of economic and policy conditions that might influence Treasury yields through their implications for policy expectations and term premiums, are depicted in Fig. 3. Primary drivers in the longer-term secular decline in nominal rates could well be the extent to which long-term inflation expectations (Fig. 3a) and interest rate movements (Fig. 3b) were stabilized during the Greenspan regime. Long-term inflation expectations were at 4.5 percent when Greenspan took office; by 1999 they had fallen to 2.5 percent, where they have remained ever since. Similarly, the volatility of long rates fell roughly in half from the time Greenspan became chairman to 1991, and have remained more or less constant since. Fig. 3a and 3b make an important point: reductions in inflation expectations and interest rate volatility may have helped reduce long-term interest rates over the course of the 1990s, but by these measures there was no further gain since 1999. The more benign budget situation (Fig. 3c) over the latter half of the 1990s also likely helped bring long rates down, although most of the fiscal improvement has since reversed. Finally, Fig. 3d shows that in most but not all tightening episodes long rates increase substantially.

Two econometric issues – both addressed later in robustness checks – arise in estimating (8). The first issue is the potential endogeneity of the regressors. We are assuming that the right-hand side variables do not respond contemporaneously to innovations to the interest rate. This assumption seems reasonable (and is widely used) with regard to macroeconomic variables, which tend to be sluggish. The assumption is somewhat less convincing, but is still maintained, with regard to survey expectations of macroeconomic variables and the current federal funds rate. The second econometric issue concerns the stationarity of the dependent variable. Over the past twenty years, U.S. interest rates and inflation expectations have drifted lower, with no apparent tendency to revert to some stable average level. If they are in fact nonstationary and cointegrated, an unrestricted regression would pick up only the long-term relationship and not the shorter-term dynamics that we are interested in. Thus, to accurately estimate the impact of other regressors, we impose an assumption about the long-run relationship between interest rates and inflation expectations that is consistent with the work of Mehra (1998). In particular, we assume that Treasury yields are non-stationary and are cointegrated with the federal funds rate and expected inflation by imposing that the coefficients on those two variables sum to one.[18] Later, as a robustness check we alleviate concerns about both issues by estimating a vector error correction model.

In our static model it is important that we can think of the foreign flows as exogenous. In Bernanke et al. (2004), exogenous foreign flows are identified through an event study approach that relies on *known* foreign exchange interventions by the Japanese government. However, the opportunity to use such a strategy is necessarily limited. The Japanese authorities acquire many U.S. Treasury bonds outside of announced interventions, and most other foreign governments accumulate U.S. securities in a more stealth manner. Our identification strategy relies instead on the flows of foreign government institutions, which include (but are not limited to) accumulation by the Bank of Japan and the People's

[17] Moreover, as we will show, our estimates of the impact of budget deficits on interest rates are not dissimilar from those in Laubach (2003) or, by extension, Engen and Hubbard (2004).

[18] This restriction assumes that real interest rates are stationary. It can be shown that imposing this restriction is identical to estimating the regression on the yield curve slope, with one of the regressors equal to the deviation of the federal funds rate from the long-run inflation rate. One could argue that all of the variables from this alternative regression are stationary. Moreover, if this restriction were not imposed, the impact of long-run inflation expectations would become implausibly large.

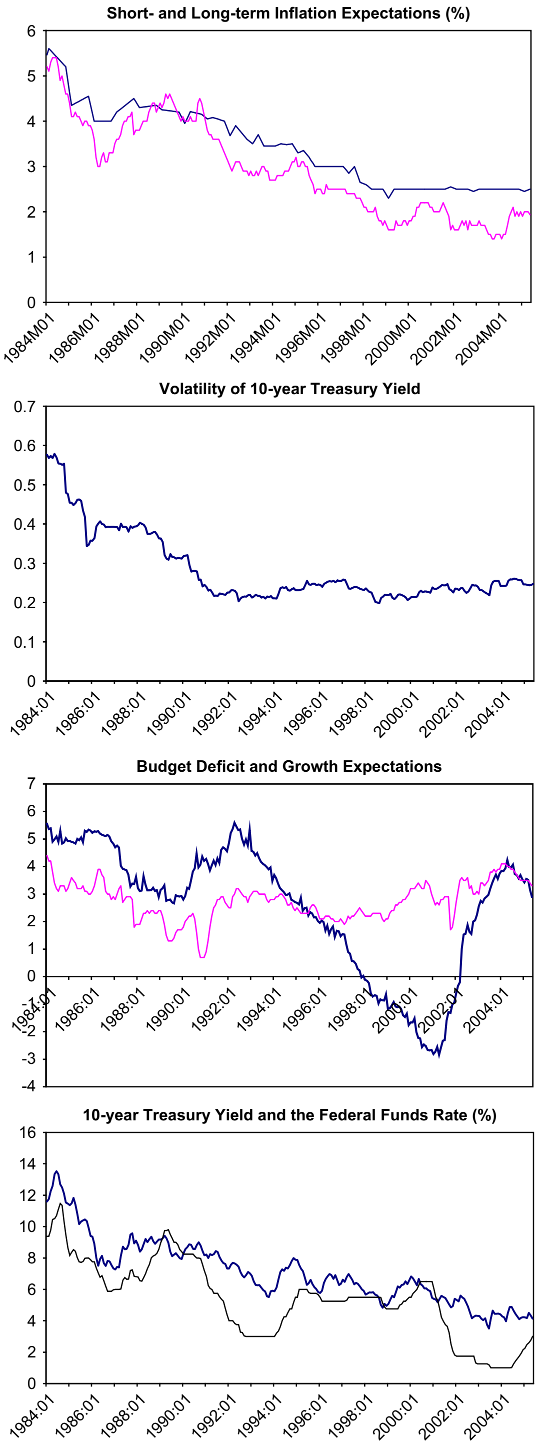

Fig. 3. Explanatory Variables. (a) Inflation expectations: one-year ahead (thin line) and ten-year ahead (thick line). (b) Interest rate volatility, computed as the standard deviation of changes in 10-year yields using a lagging 36-month window. (c) One-year ahead growth expectations (thin line) and structural budget deficit scaled by GDP (thick line). (d) Target federal funds rate (thin line) and the 10-year yield (thick line).

Bank of China, as well as the recycling of petrodollars. We consider these flows to be exogenous to our model because few governments treat their foreign reserves as a portfolio to optimize; foreign governments typically have broad objective functions that place a substantial weight on the likely impact of domestic economic policies (Dooley et al., 2004).

Regression results for the model of the 10-year yield that includes our measures of foreign flows (constructed as 12-month flows scaled by lagged GDP) are presented in Table 1. Our baseline regression is presented in column (1). Foreign flows exhibit a significant negative impact on long rates, with 12-month flows of 1 percent of GDP being associated with a 19 basis point reduction in long rates. In the baseline regression, the control variables are all significant and have the expected signs. Higher inflation and growth expectations are associated with higher long-term rates. Declining interest rate volatility lowers long rates, and, in line with the results in Laubach (2003), a one-percentage point increase in the deficit-to-GDP ratio increases long rates by 14 basis points. A one-percentage point increase in short (3-month) rates results in a 37 basis point increase. Overall, the estimates suggest that about half of the decrease in long rates through the 1990s owed to the substantial decreases in long-term inflation expectations and long rate volatility. In the conundrum phase that began in 2004, the baseline regressions – in conjunction with the paths of explanatory variables (Fig. 3) – indicate that downward pressure on long rates was coming from foreign flows and a reduction in budget deficits and growth expectations that offset the effects of increasing short rates and increasing inflation expectations.

Reported foreign official flows also exhibit a significant negative impact on long rates (column 2). Results for real rates (columns 3 and 4) are similar: Compared to the regressions for nominal rates, the coefficient estimates on the foreign flows variables are smaller, but foreign flows still significantly impact real long-term rates. We also re-estimate our regressions starting after two important changes in monetary policy that occurred over the course of our sample. In August 1987, Alan Greenspan became Chairman of the Federal Reserve Board. In February 1994, the Fed began announcing the target fed funds rate; before then, market participants had to infer the Fed's intentions by observing its actions in the market. If we start our sample at either of these dates (columns 5 and 6), our main results are unchanged.

The coefficients on our two measures of capital flows differ substantially, but their impact on long-term nominal rates is similar (Fig. 4a). Note that the graph is constructed to show how much lower U.S. rates are in comparison with the case of zero inflows. Using benchmark-consistent flows, had the twelve months ending in May 2005 seen zero foreign official purchases of U.S. Treasury and agency bonds, our estimates suggest that ceteris paribus U.S. long rates would be about 80 basis points higher. The impact using TIC-reported foreign official flows – which, as noted, represent a lower bound – was 50 basis points at the end of the sample.

Fig. 4b indicates that the model with foreign flows tracks long-run rates well (but not perfectly), and that recent long-term rates are more or less in line with fundamentals.[19] To be sure, the figure shows that the model could be improved, as, for example, a surge in rates in the mid-1990s is not picked up by the model.

Our results might seem to be strikingly large. But, as Table 2 shows, foreigners have become major participants in U.S. bond markets, holding over half the U.S. Treasury bond market and almost one-quarter of all U.S. bonds. Gone are the days of the late 1970s when foreigners held less than 5 percent of the U.S. bond market. Moreover, our results are in line with those of other researchers. For example, Laubach (2003) found that a one-percentage-point increase in the budget deficit would increase long rates by 25 basis points. Over the course of 2002 and 2003 the budget deficit increased from near zero to 4 percent of GDP, which, according to the Laubach estimates, would imply a 100-basis-point impact on long rates. If we witnessed a similarly dramatic movement in foreign flows, our results would imply a similar impact on long rates. Bernanke et al. (2004), in an event study of Japanese announced interventions, found that each $1 billion of intervention in the Treasury market depressed U.S. long

[19] In an earlier version (Warnock and Warnock, 2005), we included foreign flows into U.S. corporate bonds in our flows measures. This completely eliminated the "conundrum" and produced materially larger results, but because we cannot be certain that those flows can be treated as exogenous to our model, we do not present them in this paper.

Table 1
Model of ten-year treasury yield.[a]

DepVar:	Nominal 10-year yield		Real 10-year yield		Nominal 10-year yield	
	(1)	(2)	(3)	(4)	(5)	(6)
π^e_{t+10}	0.628*** (19.32)	0.629*** (18.97)			0.614*** (20.25)	0.586*** (17.01)
$\pi^e_{t+1} - \pi^e_{t+10}$	0.431** (2.02)	0.486** (2.24)	−0.013 (0.06)	0.028 (0.13)	−0.091 (0.50)	−0.092 (0.39)
y^e_{t+1}	0.145** (1.98)	0.137** (1.97)	0.239*** (3.28)	0.240*** (3.38)	−0.018 (0.30)	−0.065 (0.82)
rp_t	4.351*** (6.15)	4.672*** (6.74)	2.345*** (3.19)	2.446*** (3.31)	2.406*** (3.57)	14.909*** (4.45)
$i_{t,3m}$	0.372*** (11.45)	0.371*** (11.20)	0.422*** (14.23)	0.420*** (14.16)	0.386*** (12.71)	0.414*** (12.01)
$deficit_{t-1}$	0.137*** (4.52)	0.134*** (4.51)	0.041 (1.58)	0.042 (1.63)	0.216*** (8.21)	0.191*** (4.90)
$Foreign_t$	−0.188*** (5.70)		−0.078** (2.50)		−0.194*** (6.54)	−0.226*** (4.13)
$Foreign\ Off_t$		−0.399*** (6.00)		−0.199*** (2.96)		
Observations	257	257	257	257	214	148
R-squared	0.897	0.891	0.807	0.806	0.837	0.838

[a] This table presents results of OLS regressions explaining the 10-year Treasury yield using domestic variables and foreign flows. The specification is generally as follows: $i_{t,10} = a + b\pi^e_{t+10} + (1-b)i_{t,3m} + c(\pi^e_{t+1} - \pi^e_{t+10}) + d(rp_t) + e(y^e_{t+1}) + f(deficit_{t-1}) + g(foreign_t) + \varepsilon_t$ where $i_{t,10}$ is the nominal 10-year Treasury yield, π^e_{t+10} and π^e_{t+1} are 10-year- and 1-year-ahead inflation expectations; $i_{t,3m}$ is the 3-month Eurodollar rate; rp_t is an interest rate risk premium; y^e_{t+1} is expected real GDP growth over the next year; $deficit_{t-1}$ is the structural budget deficit (scaled by lagged GDP); and $foreign_t$ is 12-month aggregate foreign flows into U.S. Treasury and agency bonds. Columns 2 and 4 include foreign official flows ($Foreign\ Off_t$) instead of aggregate flows. Columns 3 and 4 have as the dependent variable the real 10-year Treasury yield, $r_{t,10}$, calculated as $i_{t,10} - \pi^e_{t+10}$ (and π^e_{t+10} is thus omitted as an explanatory variable). In all columns, *t*-statistics, computed using standard errors that are robust to heteroskedasticity and serial correlation, are reported in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Constants included but not reported. The sample is monthly from January 1984 to May 2005, except in Columns 5 and 6, which begin in August 1987 and February 1994. Yields are measured as percentages.

rates by 0.7 basis points. Foreign inflows of $100 billion a year (or even $200 billion) are not uncommon, so our magnitudes are not exorbitant when compared with those in Bernanke et al. (2004). Indeed, one interpretation is that our results generalize their event study findings.

The reader might wonder where the foreign flows are coming from. While country attribution is arguably the weakest aspect of the TIC data, it tends to be of decent quality for a group of countries in East Asia. Panel (a) of Fig. 5 decomposes foreign inflows into U.S. government bonds into those arising from Japan, China, Hong Kong, Taiwan, and Korea (thick line) and those arising from other countries (thin line). From the former group comes the vast majority of foreign official accumulation of U.S bonds; East Asian purchases peaked in the summer of 2004, when Japanese accumulation slowed considerably. The latter group includes, among other things, the recycling of petrodollars; these other inflows were still surging at the end of the sample, perhaps owing to rising oil revenues. Accordingly, the impact of East Asian accumulation (Panel (b)) was only 38 basis points at sample-end, down from a high of 78 basis points, while other inflows are accountable for a 30 basis point reduction of the 10-year yield.[20]

3.2. Foreign inflows and other U.S. interest rates

While the primary focus of our paper is on long-term Treasury yields, in Table 3 we present results for other long-term interest rates as well as short-term rates. We first re-estimate the regressions for corporate bond yields (for both Moody's Aaa and Baa) as well as a 30-year fixed mortgage rate.[21] While the coefficient estimates for some variables differ somewhat from those in our benchmark regressions, the drivers are similar. In particular, these other long rates tend to be driven by inflation and growth

[20] Impacts are computed from a model (not shown, but available from the authors) that is identical to that of Table 1 column 1, with the exception that the flows are broken out into East Asian and Other. The coefficients are −0.27 (East Asia) and −0.14 (Other); both are highly significant.

[21] The corporate bond rate data is from the Federal Reserve Board H.15 statistical release (www.federalreserve.gov/releases/h15/). Mortgage rate data are from Freddie Mac's Primary Mortgage Market Survey (www.freddiemac.com/pmms/pmms_archives.html).

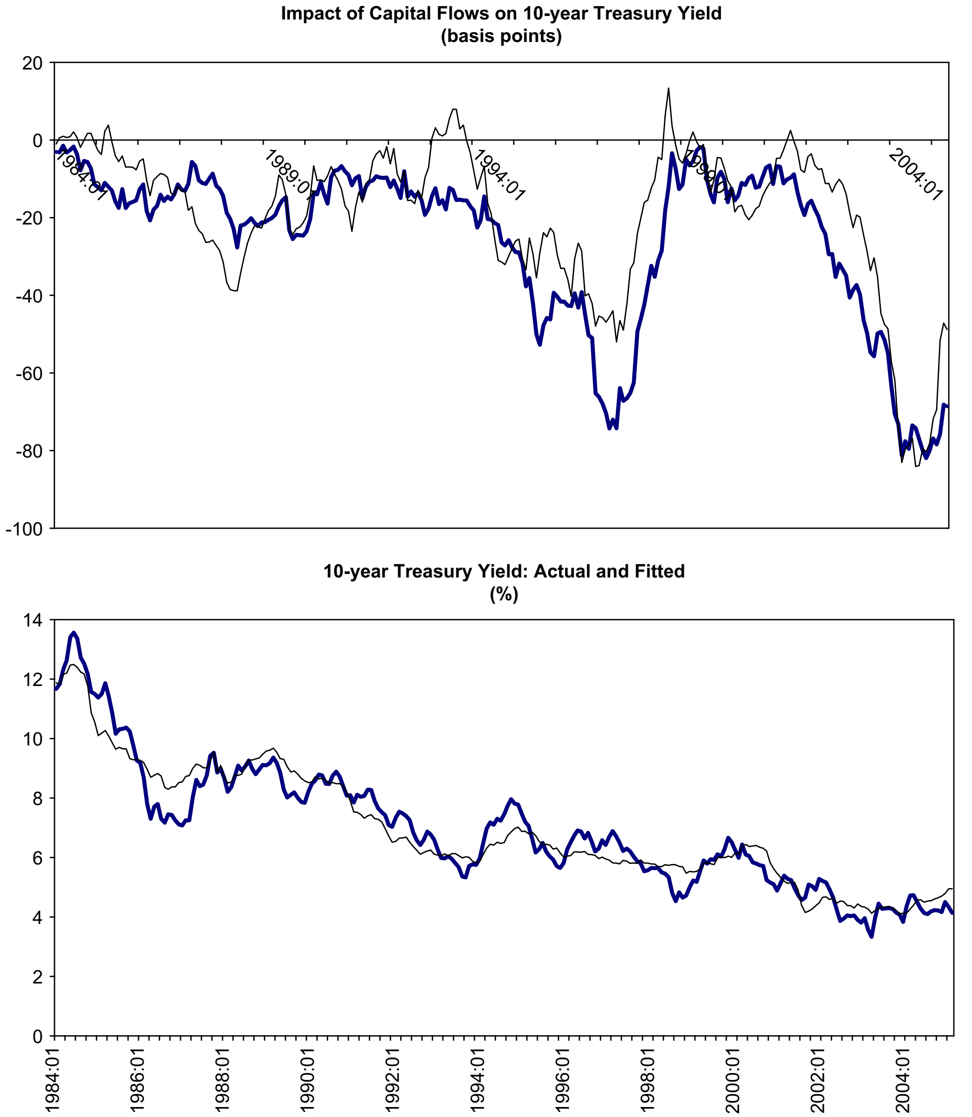

Fig. 4. Impact of Foreign Flows into US Bonds on 10-year Treasury Yields. (a) Impact is calculated as one-year flows time the coefficient estimates on foreign flows in Columns 1 (thick line) and 2 (thin line) of Table 1. (b) Fitted values (thin line) are calculated from the regression in Column 1 of Table 1.

expectations as well as risk premiums and policy variables. Moreover, foreign flows exhibit a substantial impact on these markets.

Short-term interest rates are more closely tied to policy rates, so we expect the impact of foreign flows to be more muted. Columns (4) and (5) confirm this for both the 2-year Treasury yield and the 1-year adjustable rate mortgage (ARM). For both, the coefficient on the foreign flows variable is about half those in previous tables, while the coefficient on the 3-month rate has increased substantially.

A comparison of the coefficients on the foreign flows variables in Tables 3 and 1 suggests that foreign flows can explain at least some of the 2004 and 2005 flattening of the yield curve. In the last year of our sample, the 10-year minus 2-year spread decreased by 147 basis points. Our regressions suggest that the

Table 2
Foreign holdings of long-term U.S. Debt securities ($ billions).[a]

		December 1978	December 1994	March 2000	June 2005
Issuer:					
Treasury	Outstanding	326	2392	2508	3093
	Foreign Owned	39	464	884	1599
	% Foreign Owned	12.0%	19.4%	35.2%	51.7%
Agencies	Outstanding	180	1982	3575	5591
	Foreign Owned	5	107	261	791
	% Foreign Owned	2.8%	5.4%	7.3%	14.1%
Corporates	Outstanding	715	3556	5713	8858
	Foreign Owned	7	276	703	1729
	% Foreign Owned	1.0%	7.8%	12.3%	19.5%
All U.S. Issuers	Outstanding	1221	7930	11,796	17,542
	Foreign Owned	51	847	1848	4119
	% Foreign Owned	4.2%	10.7%	15.7%	23.5%

[a] Source: Table 2 of Treasury Department et al. (2005, 2006).

differential impacts of foreign flows on these rates are associated with about 50 basis points of this flattening.

3.3. VECM estimation

In this section we follow Bandholz et al. (2007) by estimating a parsimonious vector error correction model of long-term yields, short-term rates, inflation expectations, and foreign flows. Because the VECM structure allows for both long-term and short-term influences, our underlying foreign variable is now foreign holdings of U.S. government bonds (*FH*).[22] In the short-run dynamics, of course, foreign holdings are differenced and become very much like flows. For inflation expectations, because 10-year expectations change only sluggishly, we use one-year expectations.

The results of the VECM estimation are in Table 4. A battery of lag tests pointed to 2 lags as being sufficient. A Johansen test indicated that with 2 lags there is one cointegrating vector. The VECM system is then

$$\begin{pmatrix} i_{t,10} \\ i_{t,3m} \\ \pi_t^s \\ FH_t \end{pmatrix} = \Gamma \begin{pmatrix} \Delta i_{t-1,10} \\ \Delta i_{t-1,3m} \\ \Delta \pi_{t-1}^s \\ \Delta FH_{t-1} \end{pmatrix} + \begin{pmatrix} \alpha^{i10} \\ \alpha^{i3m} \\ \alpha^{\pi} \\ \alpha^{FH} \end{pmatrix} \left(1 \beta^{i3m} \beta^{\pi} \beta^{FH} \right) \begin{pmatrix} i_{t-1,10} \\ i_{t-1,3m} \\ \pi_{t-1}^s \\ FH_{t-1} \end{pmatrix} + \varepsilon_t. \tag{9}$$

Table 4 shows that α^{i10} is negative and β^{FH} is positive, indicating that in the long-run dynamics there is a negative relationship between foreign holdings and long-term U.S. interest rates. The coefficient on ΔFH_{t-1} is also negative, indicating a negative relationship between changes in foreign holdings and long-term rates. The results from the VECM estimation are consistent with our baseline static regressions: the surge in foreign ownership of U.S. bonds has put downward pressure on long-term U.S. rates.

4. Conclusion

This paper represents an attempt at analyzing the impact of foreign flows on a large developed economy. While we remind the reader that the *ceteris paribus* caveat strongly applies to our main

[22] The foreign holdings variable, available starting December 1984, is from Bertaut and Tryon (2007). It is completely consistent with our benchmark-adjusted flows as it is essentially the h_t in our equation (5). Moreover, Bertaut and Tryon's adjusted flows (plus gap) series yield qualitatively similar results for flows regressions such as in Tables 1 and 3.

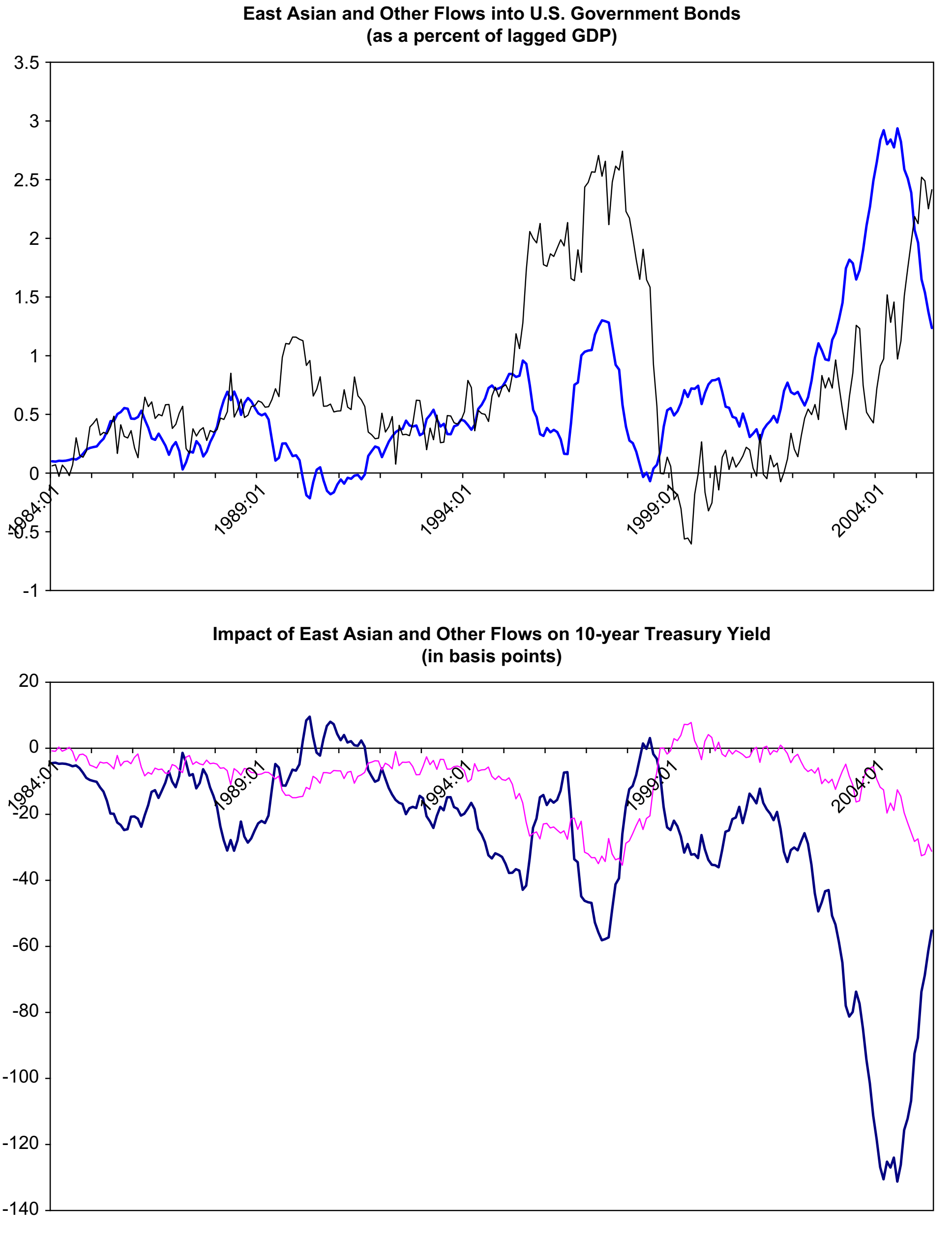

Fig. 5. Decomposition of Foreign Flows. (a) Flows decomposed into those originating from East Asia* (thick line) and elsewhere. (b) Impact of East Asian* (thick line) and other inflows. *In this exhibit, East Asia refers to Japan, China, Hong Kong, Taiwan, and Korea.

(partial equilibrium) results, our work suggests that large foreign purchases of U.S. government bonds have contributed importantly to the low levels of U.S. interest rates observed over the past few years. In the hypothetical case of zero foreign accumulation of U.S. government bonds over the course of an entire year, long rates would be 80 basis points higher.

Our results have several implications. Foreign inflows, by depressing long-term U.S. rates, make Fed policy less restrictive than otherwise and spur U.S. economic activity. One would expect the most

Table 3
Models of other interest rates.[a]

	CorpAaa	CorpBaa	Mtg30	i2	Mtg1
	(1)	(2)	(3)	(4)	(5)
π^e_{t+10}	0.761***	0.827***	0.623***	0.161***	0.503***
	(30.91)	(29.7)	(23.49)	(6.28)	(19.94)
$\pi^e_{t+1} - \pi^e_{t+10}$	0.113	0.068	0.039	0.078	−0.091
	(0.71)	(0.41)	(0.26)	(0.51)	(0.61)
y^e_{t+1}	0.141**	0.092	0.169***	0.152***	0.278***
	(2.36)	(1.49)	(2.84)	(2.73)	(4.4)
rp_t	5.019***	7.947***	5.466***	1.287**	5.217***
	(9.42)	(13.81)	(8.68)	(2.33)	(7.34)
$i_{t,3m}$	0.239***	0.173***	0.377***	0.839***	0.497***
	(9.71)	(6.2)	(14.2)	(32.75)	(19.74)
$deficit_{t\text{-}1}$	−0.016	−0.022	0.090***	0.067***	−0.125***
	(0.74)	(0.94)	(3.53)	(2.81)	(5.18)
$Foreign_t$	−0.266***	−0.350***	−0.266***	−0.040*	−0.200***
	(9.23)	(11.57)	(10.2)	(1.73)	(10.08)
Observations	257	257	257	257	257
R-squared	0.921	0.926	0.911	0.917	0.921

[a] OLS regressions explaining the Aaa corporate bond rate (column 1), Baa corporate bond rate (column 2), 30-year fixed mortgage rate (column 3), 2-year Treasury yield (column 4), and 1-year ARM (column 5). The general specification is as follows: $i_t = a + b\pi^e_{t+10} + (1-b)i_{t,3m} + c(\pi^e_{t+1} - \pi^e_{t+10}) + d(rp_t) + e(y^e_{t+1}) + f(deficit_{t-1}) + g(foreign_t) + \varepsilon_t$ where i_t is the nominal interest rate (Aaa, Baa, 30-year fixed, 2-year Treasury, or 1-year ARM); π^e_{t+10} and π^e_{t+1} are 10-year- and 1-year-ahead inflation expectations; $i_{t,3m}$ is the 3-month Eurodollar rate; rp_t is an interest rate risk premium; y^e_{t+1} is expected real GDP growth over the next year; $deficit_{t-1}$ is the structural budget deficit (scaled by lagged GDP); and $foreign_t$ is 12-month aggregate foreign flows into U.S. Treasury and agency bonds scaled by lagged GDP. In all columns, t-statistics, computed using standard errors that are robust to heteroskedasticity and serial correlation, are reported in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Constants included but not reported. The sample is monthly from January 1984 to May 2005. Yields are measured as percentages.

interest-rate sensitive sectors, such as housing, to bear the bulk of this effect; related to that, we show that U.S. mortgage rates are also depressed by the foreign inflows. Also, because short rates have been more tightly anchored to policy rates, another implication is that foreign flows help to flatten the yield curve.

One major contribution of this paper is that it highlights issues with reported capital flows data and shows the reader how to adjust the data to correct for these issues. The technique presented here is now, with only minor modifications, endorsed by the Federal Reserve. We urge the interested reader to consult Bertaut and Tryon (2007) and their associated, updated dataset.

We leave much for future work. Areas for further research include folding international flows into macro-finance models of interest rates and expanding our analysis to a multi-country model.

Table 4
Vector error correction model.[a]

	Cointegrating equation (Levels)	Error correction (Δs)
α^{i10}		−0.101 [3.75]
i_{10}	1	0.303 [3.94]
i_{3m}	−0.214 [2.82]	−0.040 [0.55]
π^e	−0.554 [1.92]	−0.251 [1.70]
FH	0.016 [2.74]	−0.031 [3.13]
Observations		242
R-squared		0.216

[a] Multivariate vector error correction estimation of the 10-year Treasury yield, 1-year-ahead inflation expectations, 3-month Eurodollar rate, and foreign holdings (*FH*) of U.S. Treasury and agency bonds (scaled by GDP). Based on various tests (available from the authors), two lags and one cointegrating vector were included in the system. In brackets are the absolute values of z-statistics. Constant included but not reported. The sample is monthly from December 1984 to March 2005. Yields are measured as percentages. For the error correction equations, only the Δi_{10} equation is shown; all others available from authors upon request.

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