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INTERNATIONAL CAPITAL FLOWS AND U.S. INTEREST RATES

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ABSTRACT

Foreign official purchases of U.S. government bonds have an economically large and statistically significant impact on long-term interest rates. Federal Reserve credibility, as evidenced by 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, however, foreign flows have become important. Controlling for various factors given by a standard macroeconomic model, we estimate that had there been no foreign official flows into U.S. government bonds over the past year, the 10-year Treasury yield would currently be 90 basis points higher. Our results are robust to a number of alternative specifications.

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I. Introduction

For emerging market economies, there is a burgeoning literature on the impact of international capital flows. For example, we have learned in recent years that in emerging markets foreign flows can result in a reduction in systematic risk (Chari and Henry, 2004) and an increase in both physical investment (Henry 2000, 2003) and economic growth (Bekaert, Harvey, and Lundblad, 2005). These positive aspects of capital flows are tempered by the role of foreign flows in spreading crises.[1]

In contrast, much less is known about the impact of capital flows on the larger economies of the world. To be sure, we know that even in the largest countries foreign flows can cause disruption—witness the ERM crisis of the early 1990s (Eichengreen, 2000)—but outside of extreme situations, evidence of any meaningful impact of capital flows on large economies is scarce. Indeed, until recently many market participants held the view that capital flows could not possibly impact interest rates in the United States.[2]

In this paper we present evidence that international capital flows have an economically important effect on the most important price in the largest economy in the world, that of the ten-year U.S. Treasury bond. Specifically, we ascertain the extent to which foreign flows into U.S. government bond markets can help explain movements in long-term Treasury yields. We address this issue at an important time. Not long ago, in the summer of 2003, short-term interest rates were very low and inflation was well contained. Over the course of 2004, the Federal Reserve began a well advertised

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[1] See, for example, Boyer, Kumagai, and Yuan (2005) and the substantial literature on sudden stops (among many others, Calvo (1998) and Mendoza and Smith (2006)).

[2] For example, as reported in "Their Money, Our Strength" (Wall Street Journal, August 5, 2004), David Malprass, Chief Economist of Bear Stearns, stated that "U.S. bond yields…have fluctuated over a wide range in response to many factors…but foreign buying…ha(s) simply not had much impact. Foreigners don't have much influence…" Many others made similar statements (although perhaps less forcefully).

tightening cycle that raised short rates while economic growth strengthened and inflation picked up, and many market observers predicted an increase in long-term U.S. interest rates that would result in substantial losses on bond positions (see, for example, Roach (2005a)). However, long-term interest rates remained quite low, puzzling market participants, financial economists, and policymakers.

We make three contributions to the literature. First, we provide a straightforward empirical presentation of the interest rate implications of the standard IS/LM model. Our second, and main, contribution is to show—by extending the empirical model—that foreign flows have had a statistically and economically significant impact on U.S. long-term rates. Our third contribution is ancillary but nevertheless important. Although the use of capital flows data has skyrocketed 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 alternative measures designed to address the deficiencies.

We begin by estimating a standard model without foreign flows. The standard model illustrates two important points. First, 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 is the improved credibility of Fed policy (as measured by reductions in both long-term inflation expectations and the volatility of long rates).[3] A sharp improvement in the fiscal situation also helped for a period, although most of those gains later evaporated. Second, at times rates seem to deviate substantially from the

[3] This is consistent with the view that the fixing of policy and inflation expectations was a crowning accomplishment of the Greenspan Fed (Poole, 2005). On the importance of fixing expectations when conducting monetary policy, see Eggertsson and Woodford (2003a, 2003b), Svensson (2001, 2003), and Krugman (1998).

standard model. For example, over the past two years many factors have pointed toward higher long rates—monetary policy has been substantially tightened, the fiscal situation has shifted from surpluses to deficits, and inflation and growth expectations have increased—but an increase in long rates has not materialized.[4]

We then extend the model to include foreign flows. To determine the impact of foreign flows on long-term U.S. interest rates, two necessary conditions must be satisfied. First, the impact must be detectable in that foreigners must be a large enough portion of the market to plausibly impact prices. Foreigners in U.S. debt markets pass this test, as they own just over half of the Treasury bond market. Second, exogenous foreign demand must be identifiable. In Bernanke, Reinhart, and Sack (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 Bank of China, as well as the recycling of petrodollars. These flows are exogenous to our model because very few governments treat their foreign reserves as a portfolio to optimize; foreign governments typically have very broad objective functions that place a substantial weight on the likely impact of domestic economic policies (Dooley, Folkerts-Landau, and Garber, 2004).

Our results with foreign flows are striking. We find in our sample spanning January 1984 to May 2005 that foreign inflows into U.S. bonds reduce the 10-year

[4] This is the "conundrum" of long-term U.S. interest rates (Greenspan, 2005).

Treasury yield by an economically and statistically significant amount. 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 90 basis points higher. Further analysis indicates that roughly two-thirds of this impact comes directly from East Asian sources. Were foreigners to reverse their flows and sell U.S. bonds in similar magnitudes, the estimated impact would be doubled.

Our paper's third contribution is ancillary but nevertheless important. We form "benchmark-consistent" capital flows measures that address issues with reported capital flows data. For the purpose of our study, the official source of U.S. capital flows, the Treasury International Capital Reporting System (TIC) data, has two deficiencies: (i) it cannot differentiate between foreign officials and other investors when the transaction goes through a third-country intermediary and (ii) TIC-reported flows greatly overestimate foreign purchases of certain types of U.S. government bonds. Because some prominent foreign governments purchase U.S. securities through offshore centers, recorded foreign *official* inflows represent only a lower bound.[5] On the other hand, the TIC data records far too many inflows into U.S. agency bonds. In particular, 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.[6] Our benchmark-consistent flows, described in full detail in the appendix, address both of these deficiencies.

Our results are robust to many alternative specifications. We impose a structure that is consistent with the potential non-stationarity of nominal rates, but to alleviate any

[5] Roach (2005b) 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).
[6] Given questions about whether long-term inflows can cover the U.S. current account deficit (Feldstein, 2006), a $158 billion overstatement in a twelve-month period is both sizeable and important.

lingering stationarity concerns we also model real rates. To eliminate the impact of short-run business cycle variations, we go a step further and model future expected real rates (the real 5-year forward rate five years hence). We present evidence that a view circulated in practitioner circles—that corporate savings importantly influence long rates (JP Morgan, 2005)—does not impact our results (nor does it appear to help explain the behavior of long rates). We also include interest rate differentials or the real exchange rate and, to alleviate potential concerns about structural breaks, 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. None of the robustness checks alter our main results.

Our results are also consistent with the notion that foreign flows are behind some of the recent flattening of the yield curve. We estimate models for a variety of U.S. interest rates—shorter term Treasury yields (2-year), 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-year) fixed mortgage rates is very similar to that on the 10-year Treasury yield, but we find that short-term rates are less affected by foreign flows, perhaps because they are deeper markets that are more closely linked to the federal funds rate. The differential effect on the two- and ten-year Treasury yields implies that over the past year foreign flows have flattened the yield curve by about 50 basis points.

Our work is related to a number of strands of the literature. Our standard model (without foreign flows) complements recent work that utilizes affine models with factors that are often unobservable (Diebold, Piazzesi, and Rudebusch, 2005; Piazzesi, 2005). Bernanke et al. (2004), perhaps the closest precursor to our work, utilizes an affine term structure model to identify (domestic) macroeconomic factors that impact yields and, separarately, includes a high frequency study of the short-run impact of announced Japanese intervention.[7] 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).[8]

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 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.

Our paper is as follows. In the next section, we lay out interest rate implications from the standard IS/LM model, show how we operationalize the model, and provide our baseline estimates. In Section III, we present our main regression results with foreign flows, as well as various robustness checks. Section IV presents regression results for a broader range of U.S. interest rates. Section V concludes. In an appendix we discuss

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[7] The simplicity of our model does not overly handicap our analysis, as the fit of our baseline model (without flows) is comparable to that of the affine term structure statistical model of Bernanke et al. (2004).

[8] 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.

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.

II. A Baseline Model of U.S. Long-Term Interest Rates

In this section we present the baseline empirical model, which can be thought of as a parsimonious representation of the IS/LM model presented in macroeconomics textbooks, and estimate the model for the period January 1984–May 2005.

II.A. Operationalizing the Standard IS/LM

The standard IS/LM model can be written as follows:[9]

$$r = \alpha_{IS} - \beta_{IS} Y \tag{1}$$

$$r = \alpha_{LM} - \frac{1}{l_r}\frac{M}{P} + \beta_{LM} Y \tag{2}$$

where equation (1) represents the IS curve, equation (2) is the LM curve, *r* is the real interest rate, *Y* is output, *M* is money supply, *P* is the price level, and

$$\alpha_{IS} = \frac{c_0 + i_0 + G - c_Y t_0 + x_0}{c_r + i_r + x_r} \tag{3}$$

$$\alpha_{LM} = \frac{l_0}{l_r} - \pi^e \tag{4}$$

[9] For a more complete treatment, see Abel and Bernanke (2005), Mishkin (2006), or any intermediate macroeconomics textbook.

The constants measure autonomous consumption (c_0), investment (i_0), taxes (t_0), and exports (x_0); the (negative of the) sensitivity of spending to changes in interest rates (c_r, i_r, x_r); and, for money demand, the autonomous component (l_0) and its sensitivity to nominal interest rates (l_r). The equilibrium real interest rate is given by

$$r = \frac{\alpha_{LM} - \frac{1}{l_r}\frac{M}{P} + \frac{\beta_{LM}}{\beta_{IS}}\alpha_{IS}}{1 + \frac{\beta_{LM}}{\beta_{IS}}} \qquad (5)$$

In the short-run IS/LM model, prices are assumed to be fixed, but the model can be appended to include a price-adjustment mechanism that kicks in when the economy is away from its full employment level; for example, prices can be assumed to increase when the economy is operating above potential.

The IS/LM is simple—dynamics are limited to the assumption concerning price adjustment—but it provides a reasonable structural specification of interest rates. It predicts that, all else equal, long-term real interest rates will increase if any of the following increases: expected future output or wealth (both of which raise c_0), government budget deficit, or expected future productivity (raises i_0). In addition, anything that results in an exogenous increase in net exports would raise interest rates. Further, interest rates will increase if any of the following occurs: monetary policy is tightened, price level increases, expected inflation decreases, or output is beyond its full-employment level.[10]

When bringing the standard model to the data, we do not aim to include every possible variable that could fit into the IS/LM framework; some degree of parsimony is, as always, desirable. Moreover, because interest rates are forward-looking asset prices, we try to rely on variables that encompass forward-looking expectations or at least can be observed in real time.

Some of the relevant variables correspond nicely with available data. Short-term (i.e., one-year-ahead) expectations of future output (y^e_{t+1}) and inflation (π^e_{t+1}) are available monthly from the Blue Chip survey. Long-term (ten-year) inflation expectations (π^e_{t+10}) are presented in the Philadelphia Fed's Survey of Professional Forecasters; we interpolate them to monthly figures.[11] We measure current monetary policy with the target federal funds rate (ff_t) rather than money supply. The credibility of monetary policy—important because interest rates are forward looking asset prices—can be captured in part by what we will call an interest rate risk premium (rp_t), which we measure as the volatility of long-term interest rates (calculated as the rolling 36-month standard deviation of changes in long rates).[12] 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 a readily available measure, the

[10] An increase in expected inflation, which decreases real rates as money demand falls, will increase nominal rates (but less than one-for-one) as long as the IS curve is not vertical (i.e., as long as spending is sensitive to interest rate changes).
[11] Ang, Bekaert, and Wei (2005) show that surveys forecast inflation quite well. Another measure of inflation expectations, TIPS, are not yet usable for time series analysis (Kwan, 2005), but are showing similar levels as the survey data we use.
[12] This risk premium in effect proxies for interest-rate and reinvestment risk.

CBO's series on the *structural* budget deficit ($deficit_{t-1}$) expressed as a percent of lagged GDP, which we interpolate 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.[13]

The impact of foreign economies on domestic interest rates in the standard IS/LM model is entirely through demand for domestic products. To the extent that a depreciation—caused perhaps by interest rate differentials—raises net exports, it would be associated with rising real interest rates. Similarly, an increase in foreign output, to the extent it falls on domestic goods, would tend to increase domestic interest rates. Along these lines, we could include in our baseline specification a real exchange rate or interest rate differentials (or both). In practice, measures of expected future output should pick up both of these features of the open economy IS/LM model—survey respondents are not asked to disregard output that serves foreign demand.[14]

Two variables in the standard IS/LM model are difficult to pin down. One is expected future productivity. Not only is current productivity difficult to measure, but in practice its impact in this model depends crucially on how it is perceived by individuals and firms. As Kohn (2003) points out, with lags in economic responses, a surge in productivity could be associated with either an increase or decrease in interest rates (depending on which aspects of the economy happen to adjust faster), making it very difficult to gauge the real-time impact of productivity on interest rates. Here again we rely on one-year ahead growth expectation to serve as a reasonable proxy. The other difficult-to-measure variable is whether output is beyond its full employment level.

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[13] 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).

[14] As we will show, interest rate differentials or exchange rates do not change our main conclusions.

Indeed, Orphanides and van Orden (2004) show that real-time forecasts of the output gap are relatively uninformative. Fortunately, here too we have an alternative. In the theoretical model, the output gap impacts interest rates only through inflation expectations, which we include directly.

II.B. Estimating the Standard IS/LM

The preceding discussion suggests that in a baseline monthly model the 10-year Treasury yield is a function of expected growth, expected inflation, a risk premium, and monetary and fiscal policy. For expected inflation, we use both a long-term (10-year) measure and, because long-term expectation evolve only slowly, a shorter-term (one-year) one that we express relative to long-term expectations ($\pi^e_{t+1} - \pi^e_{t+10}$).

Explanatory variables are presented in Figure 1. A primary driver in the longer-term secular decline in nominal rates could well be the credibility of the Greenspan Fed. Indeed, the extent to which long-term term inflation expectations (Fig. 1a) and interest rate movements (Fig. 1b) have been stabilized is remarkable. 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.[15] The more benign budget situation (Fig. 1c) over the latter half of the 1990s also likely helped bring long rates down, although most of the fiscal improvement has since reversed. Finally, Figure 1d depicts what many have focused on as a major recent surprise. The Fed has tightened considerably since mid-

[15] Figures 1a and 1b make an important point. Increased Fed credibility may have helped reduce long-term interest rates over the course of the 1990s, but by these measures there was no further gain from credibility since 1999.

2004, and in most previous tightening episodes, a sharp increase in short rates such as we have witnessed over the past year would have resulted in a sizeable increase in long rates. But, this time, despite the sharp tightening of monetary policy, long rates have remained more or less constant at a historically low level.

A final technical note before we turn to the baseline regressions. When modeling nominal rates 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.[16] As we will show, when we model real interest rates, which are stationary, our main results hold.

Table 1 presents regression results for the baseline model of nominal and real 10-year Treasury yields estimated using month-average data from January 1984 to May 2005. For nominal long rates (column 1), the most significant drivers of long-term Treasury yields are expected long-run inflation, the risk premium, the size of the structural budget deficit, and the level of the federal funds rate. 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 24 basis points. A one-percentage-point increase in long-term inflation expectations tends to increase nominal long rates by 57 basis points, and one percentage point of Fed tightening results in a 43 basis point increase. The estimates suggest that much of the

[16] 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.

decrease in long rates through the 1990s may have owed to improved Fed credibility: the substantial decrease in long-term inflation expectations and long rate volatility accounts for about half of the decrease in long rates over the decade.[17]

Real long-term rates, defined as $i_{10} - \pi^{e}_{t+10}$, have fluctuated within a band between 2 and 4 percent over the sample period. The regression (column 2) shows that real rates are also significantly impacted by the risk premium and the federal funds rate. In contrast to nominal rates, higher expected growth, but not higher budget deficits, is associated with higher real rates.

III. The Impact of Foreign Flows on U.S. Interest Rates

The standard macro model provides a reasonable representation of movements in long-term interest rates. However, given recent conditions, it predicts rising rates over the past few years when in actuality rates have remained roughly constant. In this section we append to the baseline model measures of exogenous foreign flows. We also present alternative models as robustness checks.

III.A. Foreign Inflows and Long-term Treasury Yields

Whether foreign inflows impact Treasury yields is an open question. Moreover, to our knowledge, little if any academic work has been done on this topic, perhaps because capital flows data are not easily interpretable.[18]

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[17] One could also argue that a dearth of shocks buffeting the economy played a role, although that is not directly testable using our model.

[18] One exception is Chinn and Frankel (2005), who speculate that recent capital flows might be diluting traditional interest rate relationships.

In this section we present our extended regression model, which uses (alternately) two measures of capital flows, depicted in Figure 2, that are intended to capture any systematic effects of exogenous inflows on Treasury yields. The first measure is our adjusted series on foreign accumulation of U.S. government bonds, which we call benchmark-consistent flows; these are discussed in detail in the appendix. The second is the TIC-reported series on foreign official purchases of U.S. government bonds. As the discussion in the appendix makes clear, we consider the benchmark-consistent flows to be the more accurate and the TIC-reported official flows to be a lower bound.

Regression results for the extended model of 10-year yield that includes foreign flows (constructed as twelve-month flows scaled by lagged GDP) are presented in Table 2. For nominal rates (columns 1 and 2), as in the domestic model, the coefficients on expected inflation, the risk premium, the size of the budget deficit, and the level of the federal funds rate are highly significant. In addition, expected growth becomes significant in these models. Because the coefficients on $(\pi^e_{t+1} - \pi^e_{t+10})$ and π^e_{t+10} are of similar magnitudes, in these specifications short-term inflation expectations appear to be substantial drivers of nominal long rates (perhaps because they adjust more rapidly). Notably, both foreign flow variables exhibit a significant negative impact on long rates. 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.

The coefficients on our two measures of capital flows differ substantially, but their impact on long-term nominal rates is very similar (Figure 3a). 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 last twelve months seen zero foreign official purchases of U.S. Treasury and agency bonds, our estimates suggest that ceteris paribus U.S. long rates would be 92 basis points higher.[19] The impact using TIC-reported foreign official flows—which, as noted, represent a lower bound—is currently 74 basis points. The impact of *reported* TIC official inflows peaked in the summer of 2004 at about 125 basis points; the reduced impact since then could owe in part to increased avoidance of U.S. intermediaries by foreign governments, especially those that are recycling petrodollars.

Figure 3b 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.[20] To be sure, the figure shows that the model could be improved, as a surge in rates in the mid-1990s is not picked up by the model.

Our results might strike the reader as being large. But, as Table 3 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

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[19] Were foreign purchases to reverse to similarly sized *sales*, the impact would be double (184 basis points).
[20] 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 current conundrum, 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.

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 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 Figure 4 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 are still surging, perhaps owing to rising oil revenues.

Accordingly, the impact of East Asian accumulation (Panel B) is currently only 55 basis points, down from a high of 130 basis points, while other inflows are now accountable for a 31 basis point reduction of the 10-year yield.[21]

[21] Impacts are computed from a model (not shown, but available from the authors) that is identical to that of Table 2 column 1, with the exception that the flows are broken out into East Asian and Other. The coefficients are -0.45 (East Asia) and -0.13 (Other); both are highly significant.

III.B. Alternative Specifications of the Extended Model

In this subsection we present some alternative specifications that we view as robustness checks.

Do Corporate Savings Solve the Puzzle?

JPMorgan (2005) incorporates a measure of corporate savings into a model of long rates; see Economist (2005a). The logic is that as the corporate sector moved from a net borrower in 2000 (with a financing gap of about 3 percent of GDP) to a net saver by 2004 (a slightly negative financing gap), their reduced demand for capital should have put downward pressure on interest rates.

To test whether corporate savings, rather than foreign flows, helps explain the puzzle, we include a measure of the corporate financing gap (scaled by GDP). Because the financing gap is available only quarterly, for this test we utilize a quarterly model. We find no evidence (Column 1, Table 4) that the increased corporate savings has put downward pressure on U.S. interest rates; indeed, the sign on the (insignificant) coefficient would suggest the opposite. Foreign flows remain economically and statistically important.[22]

Eliminating the Effect of Short-run Business Cycle Variations

To address any potential concerns about the impact of short-run dynamics and business cycle fluctuations on our regressions, we analyze real long-dated forward rates that help address any endogeneity concerns regarding our regressors. Our earlier

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[22] We were surprised to find results that differed so greatly from those in JPMorgan (2005), so we investigated further. We utilized, as they did, data on non-financial firms' financing gap from the Federal Reserve's Flow of Funds Accounts (Table F.102 line 59). JPMorgan appends a measure for financial firms, although we were unable to uncover such a measure. But their appended series is too similar to the reported one to explain the difference in results, which appears to owe to the sample; their sample extends back to 1959, and the few-year period ending 1984:Q1 experienced very high interest rates and a very high financing gap.

regressions assume that the right-hand side variables do not respond contemporaneously to innovations to the interest rate, an assumption that is reasonable and 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. Modeling long-dated forward rates—specifically, the real 5-5 forward rate (i.e., the five-year rate five years hence)—using only longer-term explanatory variables alleviates this concern.[23] Abstracting from business cycle considerations, real long-term forward rates are lower when risk premiums decrease and budget deficits are smaller (Column 2, Table 4). Moreover, the coefficient estimates on the foreign flows variables are consistent with our main results. Even abstracting from the potentially confounding effects of business cycle fluctuations, foreign flows have a statistically and economically significant impact on U.S. interest rates.

Alternative Samples

There were at least two important changes in monetary policy 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 (Table 4, columns 3 and 4), our main results are unchanged.

[23] Because data on 5-5 forward rates do not extend back to January 1984, we form these rates using the standard technique of Shiller, Campbell, and Schoenholtz (1983).

Incorporating Interest Differentials and Exchange Rates

In the standard IS/LM model, interest rate differentials should impact the domestic interest rate only to the extent to which they impact the exchange rate. In turn, the channel from the exchange rate to domestic interest rates should go through net exports, which is captured in our main regressions by the variable that measures expected growth. That said, in Table 5 we directly include (real) interest rate differentials, $r^* - r$, and the year-over-year change in the real exchange rate (*rer*).[24] The results are counter to what the model predicts. That is, higher foreign interest rates (relative to U.S. rates) are associated with a *decrease* in U.S. rates, and an appreciation—which should switch demand from U.S. to foreign goods—is associated with *higher* U.S. rates. Of course, our simple model cannot adequately pick up J-curve effects, which is one reason we prefer to rely on the expected growth variable in the baseline regressions.

IV. The Impact of Foreign Inflows on Other U.S. Interest Rates

While the focus of our paper is on long-term Treasury yields, for further investigation we present results for other long-term interest rates as well as short-term rates. Our regression specifications are as in the previous section, although we include one extra variable, $cycle_t$, a real-time indicator of the state of the business cycle.[25] The

[24] The (real) interest rate differential is the spread of foreign rates over U.S. rates, where foreign rates are computed as a simple average of long rates in Germany, Japan, and the UK. Year-over-year changes in the real exchange rate are computed using the Federal Reserve's broad real index, for which an increase represents dollar appreciation.

[25] Using real-time data from the Philadelphia Fed, we compute $cycle_t$ as the deviation of current real-time employment growth from its 36-month average. There is a potential role for $cycle_t$ in our main regressions, as Gurkaynak, Sack, and Swanson (2005) show that long-term rates adjust to employment reports. But including $cycle_t$ in our regressions for the 10-year Treasury yield would not alter our results,

business cycle variable plays two roles in what follows. When employment growth is very weak, risk premiums on some of the riskier bonds we consider below might widen, so *Cycle* may capture a risk premium effect (separate from the interest rate risk premium). Also, when we turn to shorter rates that adjust very quickly, there is a chance that our expectations data are sluggish. If so, the real-time business cycle variable could pick up instantaneous adjustments in expectations.

IV. A. Results for Other Long-Term Rates

To see if our results also hold for a broader set of U.S. long-term interest rates, we re-estimate the regressions for corporate bond yields (for both Moody's Aaa and Baa) as well as a 30-year fixed mortgage rate.[26] The results are presented in Table 6. 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 expectations as well as risk premiums and policy variables. Moreover, foreign flows exhibit a substantial impact on these markets.

IV. B. Results for Short-Term Rates

Short-term interest rates are more closely tied to the federal funds rate, so we expect the impact of foreign flows to be more muted. Table 7 confirms 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

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perhaps because Gurkaynak et al. argue that surprises from employment reports impact long rates through changes in inflation expectations (for which we control).

[26] 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).

coefficient on the federal funds rate has increased substantially. Note too that the coefficient on the business cycle indicator plays different roles in these regressions. For ARMs, cyclical weakness is associated with higher rates, perhaps this owes to greater demand for the lower rates of ARMs when unemployment is temporarily high. In contrast, for short-term Treasury yields, the coefficient on the business cycle indicator is positive; cyclical weakness is associated with a decrease in short rates.

A comparison of the coefficients on the foreign flows variables in Tables 7 and 2 suggests that foreign flows can explain at least some of the recent 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 differential impacts of foreign flows on these rates are associated with 52 basis points of this flattening.

V. Conclusion

This paper represents a first attempt at analyzing the impact of foreign flows on a large developed economy. Past work has taught us much about the role of foreign investors in emerging markets. We can now add our results to this literature: Foreign flows have an economically large and statistically significant impact on long-term U.S. interest rates.

Our work also 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 almost 100 basis points higher. Because some of the foreign flows owe to the recycling of petrodollars, our results suggest a mitigating factor that might be reducing some of the bite of higher oil prices.

We caution that although we present a multitude of robustness tests, it is possible that our results overstate the effects of foreign flows. One might suspect that other factors not completely captured by the regressors were putting downward pressure on interest rates over this period. Those other factors include FOMC statements suggesting that policy accommodation would be removed only slowly, worries about the risk of deflation, or perhaps a more benign outlook for inflation than suggested by the Philadelphia Fed's surveys. Still, the facts we present are suggestive of sizeable effects and eminently plausible given that foreigners currently hold more than half of the U.S. Treasury bond market.

We also remind the reader that the *ceteris paribus* caveat strongly applies to our partial equilibrium results. We quantify the impact were all else to remain unchanged. However, were (for example) East Asian governments to spark the effect we presented, others could step in and buy, thereby alleviating the impact on U.S. rates. We can think of these "others" as market participants, potentially attracted by higher yields, but the U.S. has one exceedingly large participant that could undo any potential effect: the Federal Reserve. Were the Fed to view the subsequent increase in U.S. long rates as undesirable, it has the power to step in and buy either the exact Treasury securities being sold or near-substitutes such as agency bonds.[27]

The literature on capital flows is blossoming, and we leave plenty for future research. It would be worthwhile to model private foreign flows to determine their impact on U.S. interest rates. A model similar to ours could be applied to other countries,

[27] See Warnock (2006) for a more complete discussion of potential Fed responses to foreign sales.

although America's exorbitant privilege (Gourinchas and Rey, 2006) and Burger and Warnock (2006) suggest that very few attract substantial foreign flows into their local currency bond markets. Finally, foreign flows should be incorporated into affine term structure models, as more of them come to identify observable macroeconomic factors.

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Appendix. Reported Capital Flows Data and Benchmark-Consistent Flows

U.S. Data on International Capital Flows

The most timely source of U.S. data on capital flows is the weekly H4.1 release of U.S. government securities held in custody at the Federal Reserve Bank of New York (FRBNY) on behalf of foreign *official* institutions (central banks and finance ministries). The weekly FRBNY custodial data are easily obtained[28] 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.[29] 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 TIC system as a whole, of which the FRBNY data is a subset. The TIC system reports monthly data on foreigners' purchases and sales of all types of long-term securities (equities as well as corporate, agency, and Treasury bonds).[30] As such, the TIC data gives a much fuller picture of international flows into U.S. securities, although they are less timely, being released six weeks after month's end.

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. Again, 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).

Comprehensive benchmark survey data of foreign holdings are 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.[31] 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 governments are not usually 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 it is well known that the TIC system is not able to correctly differentiate between foreign officials and other foreign investors (such as pension funds, oil stabilization funds, insurance companies, and others) when the trade is made

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[28] A memo item at the bottom of the first page 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).

[29] 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.

[30] 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.

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

through a third-country intermediary, we will 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.

Figure A1 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' purchases of agency bonds.[32]

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.[33] Reporting to the surveys is mandatory, with penalties for noncompliance, and the data received are subjected to extensive

[32] 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.

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

analysis and editing. For liabilities surveys (of foreign holdings of U.S. securities), the reporters consist primarily of large custodians (banks and broker-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:

$$nh_t = nh_{t-1}(1+r_t) + gp_t(1-tc) - gs_t(1+tc) \qquad \text{(A1)}$$

where

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

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 (A1) 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:

$$gap_T = bh_T - nh_T \qquad \text{(A2)}$$

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:

$$adj_t = gap_T * adjfactor * \frac{gp_t + gs_t}{\sum_{k=1}^{T} gp_k + gs_k} \qquad \text{(A3)}$$

where periods *1* and *T* span the entire inter-survey period. For each inter-survey period, everything on the right side of (A3) is given except *adjfactor*, which we choose to minimize the distance at time T between benchmark holdings and our adjusted holdings estimates:

$$\min\left|bh_T - h_T\right| \tag{A4}$$

where our adjusted holdings estimates, h_t, evolve according to

$$h_t = h_{t-1}(1+r_t) + gp_t(1-tc) - gs_t(1+tc) + adj_t \tag{A5}$$

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

$$h_t \geq 0 \tag{A6}$$

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 (A3), our benchmark-consistent flows, or net purchases (np_t), are given by

$$np_t = gp_t(1-tc) - gs_t(1+tc) + adj_t \tag{A7}$$

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 (Fig. A1), 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.[34]

[34] The BEA also publishes international flows data in their 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 feel it is warranted. BEA's determines whether TIC flows data should be altered by consulting the infrequent benchmark positions data, so their adjustment is similar in spirit to ours. Benchmark-consistent flows for the component of overall bond inflows are not available prior to 1994, so pre-1994 our preferred measure utilizes reported TIC data.

Table 1: Baseline Model of Ten-Year Treasury Yield

Column 1 presents baseline OLS regressions explaining the 10-year Treasury yield, $i_{t,10}$. The specification is as follows:

$$i_{t,10} = a + b\pi^e_{t+10} + (1-b)\,ff_t + c(\pi^e_{t+1} - \pi^e_{t+10}) + d(rp_t) + e(y^e_{t+1}) + f(deficit_{t-1}) + \varepsilon_t$$

where π^e_{t+10} and π^e_{t+1} are 10-year- and 1-year-ahead inflation expectations; ff_t is the federal funds rate; rp_t is an interest rate risk premium; y^e_{t+1} is expected real GDP growth over the next year; and $deficit_{t-1}$ is the structural budget deficit (scaled by lagged GDP). **Column 2** is identical except that the dependent variable is 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). Standard errors are reported in parentheses (robust to heteroskedasticity and serial correlation). Highly significant coefficients (at the 1% level) are shown in bold; [a] and [b] denote significance at the 5% and 10% levels, respectively. Constants included but not reported. The sample is monthly from January 1984 to May 2005. Yields are measured in percentage points.

Dependent Variable:	Nominal 10-year yield	Real 10-year yield
	(1)	(2)
π^e_{t+10}	**0.57 (0.03)**	
$\pi^e_{t+1} - \pi^e_{t+10}$	0.22 (0.19)	0.01 (0.22)
y^e_{t+1}	0.07 (0.07)	**0.22 (0.07)**
rp_t	**5.37 (0.64)**	**3.02 (0.79)**
ff_t	**0.43 (0.03)**	**0.42 (0.03)**
$deficit_{t-1}$	**0.24 (0.03)**	0.04 (0.03)
R^2	0.89	0.80

Table 2: Extended Model of Ten-Yield Treasury Yield

Columns 1 and 2 present results of OLS regressions explaining the nominal 10-year Treasury yield, $i_{t,10}$, using domestic variables and a foreign flows variable. The specification is as follows:

$$i_{t,10} = a + b\pi^e_{t+10} + (1-b)\,ff_t + c(\pi^e_{t+1} - \pi^e_{t+10}) + d(rp_t) + e(y^e_{t+1}) + f(deficit_{t-1}) + g(foreign_t) + \varepsilon_t$$

where π^e_{t+10} and π^e_{t+1} are 10-year- and 1-year-ahead inflation expectations; ff_t is the federal funds 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 foreign official flows into U.S. Treasury and agency bonds, either benchmark-consistent (columns 1 and 3) or TIC-reported (columns 2 and 4), both scaled by lagged GDP. **Columns 3 and 4** are identical except that the dependent variable is 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, standard errors are reported in parentheses (robust to heteroskedasticity and serial correlation). Highly significant coefficients (at the 1% level) are shown in bold; [a] and [b] denote significance at the 5% and 10% levels, respectively. Constants included but not reported. The sample is monthly from January 1984 to May 2005. Yields are measured in percentage points.

DepVar:	Nominal 10-year yield		Real 10-year yield	
	(1)	(2)	(3)	(4)
π^e_{t+10}	**0.64 (0.03)**	**0.67 (0.03)**		
$\pi^e_{t+1} - \pi^e_{t+10}$	**0.65 (0.19)**	**0.84 (0.20)**	0.17 (0.22)	0.19 (0.23)
y^e_{t+1}	**0.26 (0.07)**	**0.24 (0.07)**	**0.22 (0.07)**	**0.22 (0.07)**
rp_t	**4.82 (0.64)**	**5.89 (0.63)**	**3.08 (0.76)**	**3.23 (0.78)**
ff_t	**0.36 (0.03)**	**0.33 (0.03)**	**0.38 (0.03)**	**0.38 (0.03)**
$deficit_{t-1}$	**0.21 (0.03)**	**0.21 (0.03)**	0.05[b](0.03)	0.05[b](0.03)
$foreign_t$	**-0.25 (0.03)**	**-0.61 (0.06)**	**-0.10 (0.03)**	**-0.22 (0.07)**
R^2	0.90	0.89	0.81	0.81

Table 3. Foreign Holdings of Long-term U.S. Debt Securities ($ billions)

		December 1978	December 1994	March 2000	June 2005
Issuer:					
Treasury	Outstanding	326	2,392	2,508	3,093
	Foreign Owned	39	464	884	1,599
	% Foreign Owned	12.0%	19.4%	35.2%	51.7%
Agencies	Outstanding	180	1,982	3,575	5,591
	Foreign Owned	5	107	261	791
	% Foreign Owned	2.8%	5.4%	7.3%	14.1%
Corporates	Outstanding	715	3,556	5,713	8,858
	Foreign Owned	7	276	703	1,729
	% Foreign Owned	1.0%	7.8%	12.3%	19.5%
All U.S. Issuers	Outstanding	1,221	7,930	11,796	17,542
	Foreign Owned	51	847	1,848	4,119
	% Foreign Owned	4.2%	10.7%	15.7%	23.5%

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

Table 4: Alternative Specifications of the Extended Model

The first column presents OLS regressions explaining the 10-year Treasury yield, $i_{t,10}$, using domestic variables, a foreign flows variable, and a corporate savings variable:

$$i_{t,10} = a + b\pi^e_{t+10} + (1-b)\,ff_t + c(\pi^e_{t+1} - \pi^e_{t+10}) + d(rp_t) + e(y^e_{t+1}) + f(deficit_{t-1}) + g(foreign_t) + h(fingap_t) + \varepsilon_t$$

where π^e_{t+10} and π^e_{t+1} are 10-year- and 1-year-ahead inflation expectations; ff_t is the federal funds 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); $foreign_t$ is 12-month benchmark-consistent foreign official flows into U.S. Treasury and agency bonds scaled by lagged GDP; and $fingap_t$ is the financing gap (from Federal Reserve Flow of Funds (Table F. 102, line 59)) scaled by GDP. In column (2), the dependent variable is future expected long rates (the real 5-5 forward rate, $r_{t,5-5}$); only longer-term domestic variables and a global foreign flows variable are included in that model. Columns (3) and (4) are the standard regressions from Table 2 column (1) but with start dates that correspond to known changes in monetary policy: August 1987 (when Greenspan became Fed Chairman) and February 1994 (when the Fed began announcing changes in the target Fed Funds rate). Standard errors are reported in parentheses (robust to heteroskedasticity and serial correlation). Highly significant coefficients (at the 1% level) are shown in bold; [a] and [b] denote significance at the 5% and 10% levels, respectively. Constants included but not reported. Unlike other regressions in this paper, the regressions in column 1 utilize a quarterly sample. Yields are measured in percentage points.

DepVar:	Nominal 10-year yield	Real 5-5 Forward Rate	Nominal 10-year yield	Nominal 10-year yield
	(1)	(2)	(3)	(4)
π^e_{t+10}	**0.59 (0.07)**		**0.64 (0.03)**	**0.58 (0.04)**
$\pi^e_{t+1} - \pi^e_{t+10}$	0.45 (0.35)		0.04 (0.16)	0.01 (0.23)
y^e_{t+1}	0.28[b](0.13)		-0.04 (0.05)	-0.09 (0.07)
rp_t	**4.82 (1.04)**	**10.2 (0.60)**	**1.88 (0.61)**	**19.7 (3.57)**
ff_t	**0.41 (0.07)**		**0.36 (0.03)**	**0.42 (0.04)**
$deficit_{t-1}$	**0.19 (0.04)**	**0.19 (0.02)**	**0.25 (0.02)**	**0.26 (0.04)**
$foreign_t$	**-0.24 (0.04)**	**-0.36 (0.03)**	**-0.24 (0.02)**	**-0.31 (0.04)**
$fingap_t$	-0.13 (0.09)			
Sample	1984:Q1 – 2005:Q1	Jan. 1984 – May 2005	Aug. 1987 – May 2005	Feb. 1994 – May 2005
R^2	0.90	0.86	0.90	0.75

Table 5: Model Including Interest Rate Differentials or Exchange Rate

The table presents OLS regressions explaining the 10-year Treasury yield, $i_{t,10}$, using domestic variables, a global foreign flows variable, and (alternately) a real interest rate differential or real exchange rate variable:

$$i_{t,10} = a + b\pi^e_{t+10} + (1-b)\,ff_t + c(\pi^e_{t+1} - \pi^e_{t+10}) + d(rp_t) + e(y^e_{t+1}) + f(deficit_{t-1}) + g(foreign_t) + h(X_t) + \varepsilon_t$$

where π^e_{t+10} and π^e_{t+1} are 10-year- and 1-year-ahead inflation expectations; ff_t is the federal funds 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); $foreign_t$ is 12-month benchmark-consistent foreign official flows into U.S. Treasury and agency bonds scaled by lagged GDP; and X_t is either a (real) interest rate differential (calculated as the spread of foreign interest rates over U.S. rates, where foreign rates are a simple average of long rates in Germany, Japan, and the UK) or year-over-year changes in the real exchange rate (given by the Federal Reserve's broad real exchange rate, for which an increase is dollar appreciation). Standard errors are reported in parentheses (robust to heteroskedasticity and serial correlation). Highly significant coefficients (at the 1% level) are shown in bold; [a] and [b] denote significance at the 5% and 10% levels, respectively. Constants included but not reported. Yields are measured in percentage points.

DepVar:	Nominal 10-year yield	Nominal 10-year yield
	(1)	(2)
π^e_{t+10}	**0.78 (0.03)**	**0.70 (0.03)**
$\pi^e_{t+1} - \pi^e_{t+10}$	**1.17 (0.19)**	**1.50 (0.17)**
y^e_{t+1}	0.05 (0.06)	0.07 (0.06)
rp_t	**2.10 (0.51)**	**4.22 (0.62)**
ff_t	**0.22 (0.03)**	**0.30 (0.03)**
$deficit_{t-1}$	**0.20 (0.02)**	**0.31 (0.03)**
$foreign_t$	**-0.32 (0.03)**	**-0.24 (0.02)**
$r^* - r$	**-0.43 (0.04)**	
rer_t		**0.07 (0.01)**
R^2	0.92	0.92

Table 6: Models of Other Long-Term Interest Rates

OLS regressions explaining the Aaa corporate bond rate (column 1), Baa corporate bond rate (column 2), and the 30-year fixed mortgage rate (column 3). The general specification is as follows:

$$i_t = a + b\pi^e_{t+10} + (1-b)\,ff_t + c(\pi^e_{t+1} - \pi^e_{t+10}) + d(cycle_t) + e(rp_t) + f(y^e_{t+1}) + g(deficit_{t-1}) + h(foreign_t) + \varepsilon_t$$

where i_t is the nominal interest rate (Aaa, Baa, or 30-year fixed); π^e_{t+10} and π^e_{t+1} are 10-year- and 1-year-ahead inflation expectations; $cycle_t$ is a business cycle indicator computed as the real-time change in employment relative to its 36-month average; ff_t is the federal funds 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 benchmark-consistent foreign official flows into U.S. Treasury and agency bonds scaled by lagged GDP. Standard errors are reported in parentheses (robust to heteroskedasticity and serial correlation). Highly significant coefficients (at the 1% level) are shown in bold; [a] and [b] denote significance at the 5% and 10% levels, respectively. Constants included but not reported. The sample is monthly from January 1984 to May 2005. Yields are measured in percentage points.

DepVar:	Aaa Corporate	Baa Corporate	30-year Fixed Mortgage
	(1)	(2)	(3)
π^e_{t+10}	**0.78 (0.02)**	**0.85 (0.03)**	**0.63 (0.03)**
$\pi^e_{t+1} - \pi^e_{t+10}$	0.34[a] (0.15)	0.26[b] (0.15)	0.21 (0.15)
y^e_{t+1}	**0.19 (0.06)**	0.14[a] (0.06)	**0.20 (0.06)**
$cycle_t$	-0.03 (0.16)	-0.34[b] (0.18)	-0.08 (0.17)
rp_t	**5.12 (0.53)**	**8.09 (0.57)**	**5.42 (0.60)**
ff_t	**0.22 (0.02)**	**0.15 (0.03)**	**0.37 (0.03)**
$deficit_{t-1}$	0.02 (0.02)	0.01 (0.02)	**0.13 (0.02)**
$foreign_t$	**-0.30 (0.03)**	**-0.37 (0.03)**	**-0.29 (0.03)**
R^2	0.92	0.93	0.94

Table 7: Regression Results for Short-Term Rates

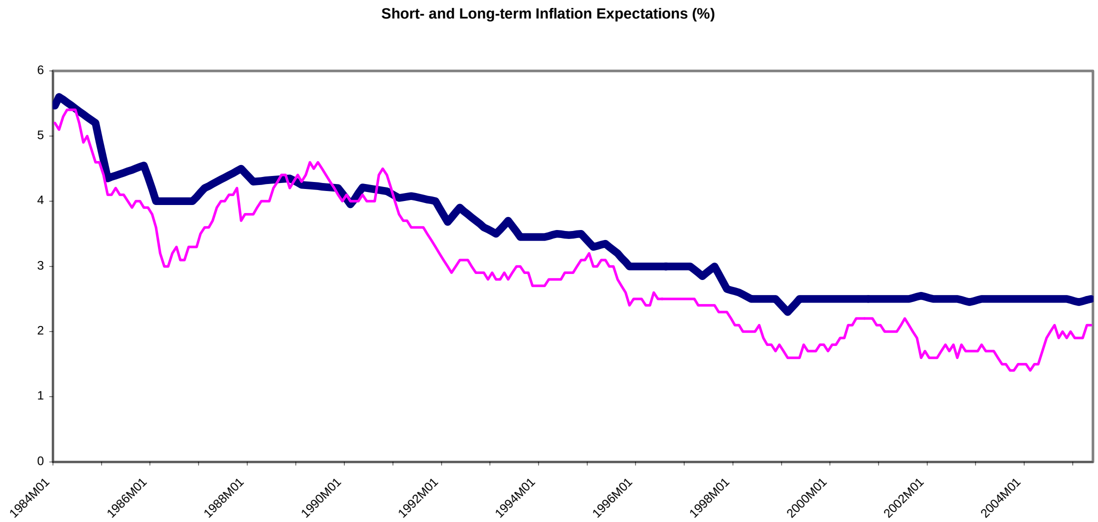
OLS regressions explaining the 2-year Treasury yield (column 1) and the 1-year ARM (column 2). The general specification is as follows:

$$i_t = a + b\pi^e_{t+10} + (1-b)\,ff_t + c(\pi^e_{t+1} - \pi^e_{t+10}) + d(cycle_t) + e(rp_t) + f(y^e_{t+1}) + g(deficit_{t-1}) + h(foreign_t) + \varepsilon_t$$

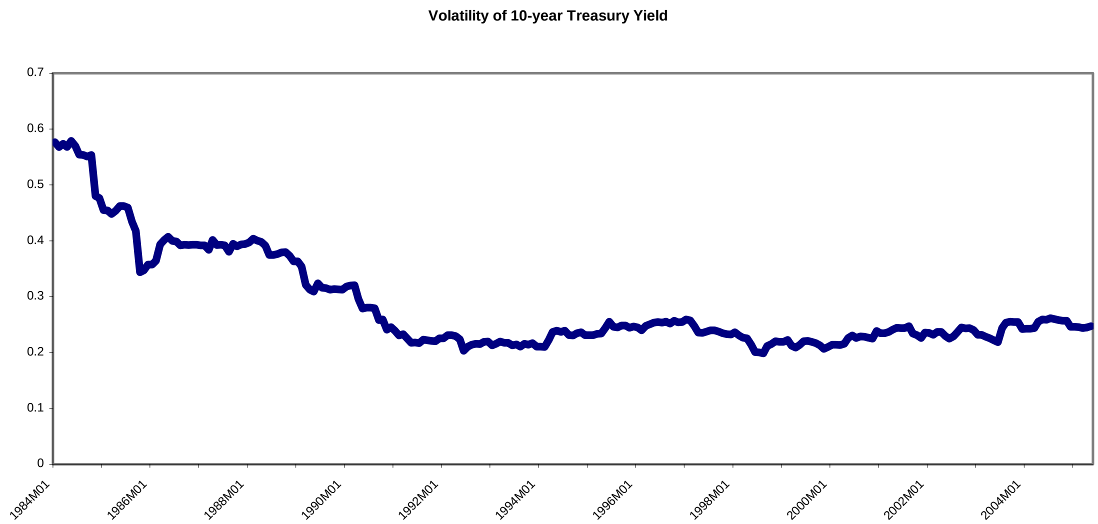
where i_t is the nominal interest rate (2-year Treasury or 1-year ARM); π^e_{t+10} and π^e_{t+1} are 10-year- and 1-year-ahead inflation expectations; $cycle_t$ is a business cycle indicator computed as the real-time change in employment relative to its 36-month average; ff_t is the federal funds rate; 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 benchmark-consistent foreign official flows into U.S. Treasury and agency bonds scaled by lagged GDP. Standard errors are reported in parentheses (robust to heteroskedasticity and serial correlation). Highly significant coefficients (at the 1% level) are shown in bold; [a] and [b] denote significance at the 5% and 10% levels, respectively. Constants included but not reported. The sample is monthly from January 1984 to May 2005. Yields are measured in percentage points.

DepVar:	2-year Treasury	1-year ARM
	(1)	(2)
π^e_{t+10}	**0.19 (0.03)**	**0.46 (0.02)**
$\pi^e_{t+1} - \pi^e_{t+10}$	0.41[a](0.16)	-0.19 (0.13)
y^e_{t+1}	**0.16 (0.06)**	**0.37 (0.05)**
$cycle_t$	**0.81 (0.19)**	**-0.79 (0.16)**
rp_t	1.51[a] (0.60)	**5.22 (0.57)**
ff_t	**0.81 (0.03)**	**0.54 (0.02)**
$deficit_{t-1}$	**0.09 (0.03)**	**-0.08 (0.02)**
$foreign_t$	**-0.11 (0.03)**	**-0.18 (0.02)**
R^2	0.95	0.96

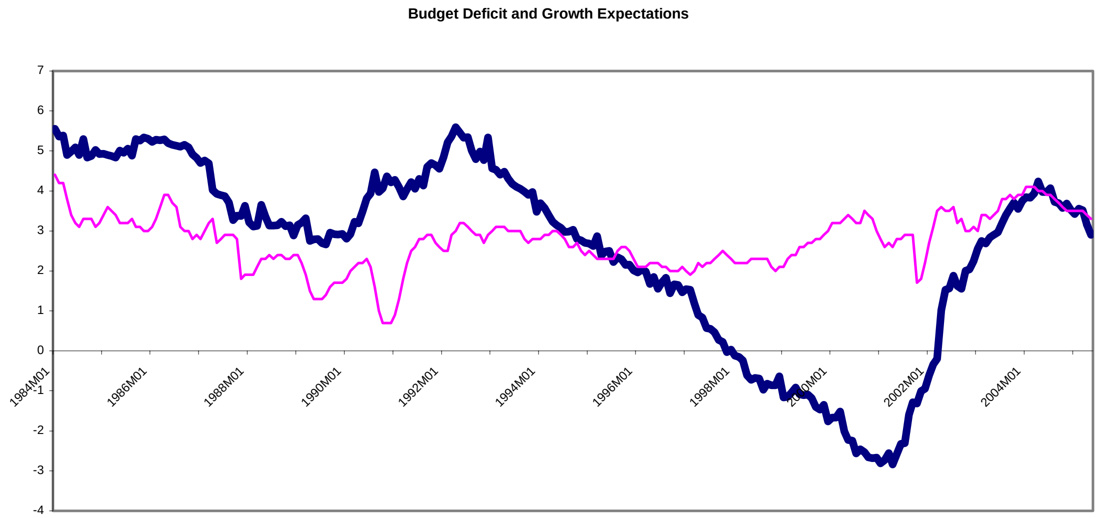
Figure 1. Explanatory Variables
(a) Inflation expectations: one-year ahead (thin line) and ten-years ahead (thick line).



(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).

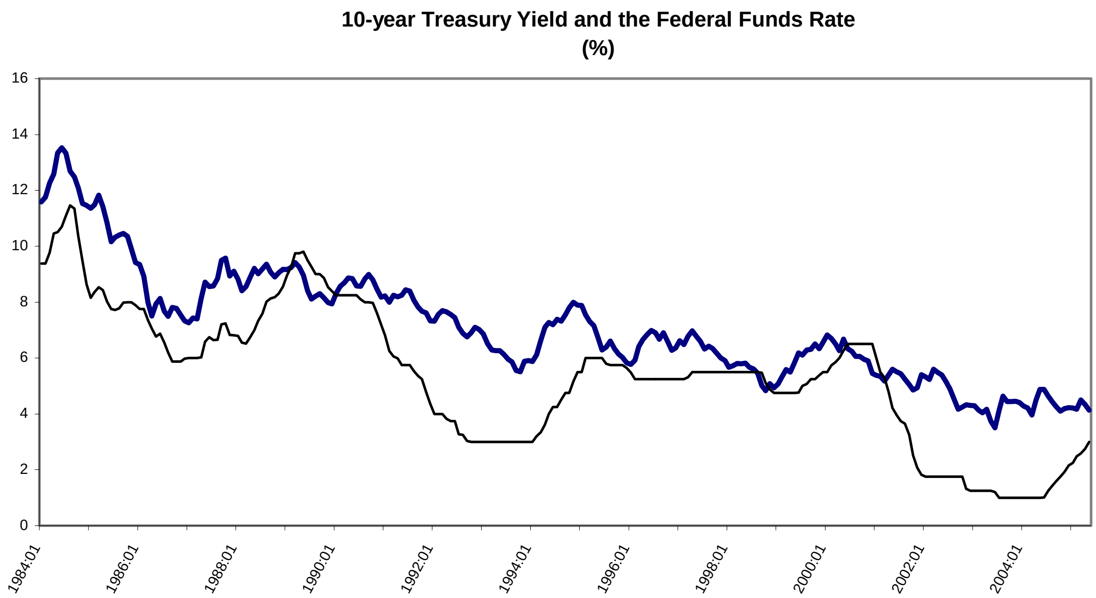


Figure 2. Foreign Inflows into U.S. Government Bonds

Both variables are 12-month flows scaled by lagged GDP. The thick line represents foreign official flows into U.S. government bonds as reported to the TIC system. The thin line is based on our benchmark-consistent flows, which are described in detail in the appendix.

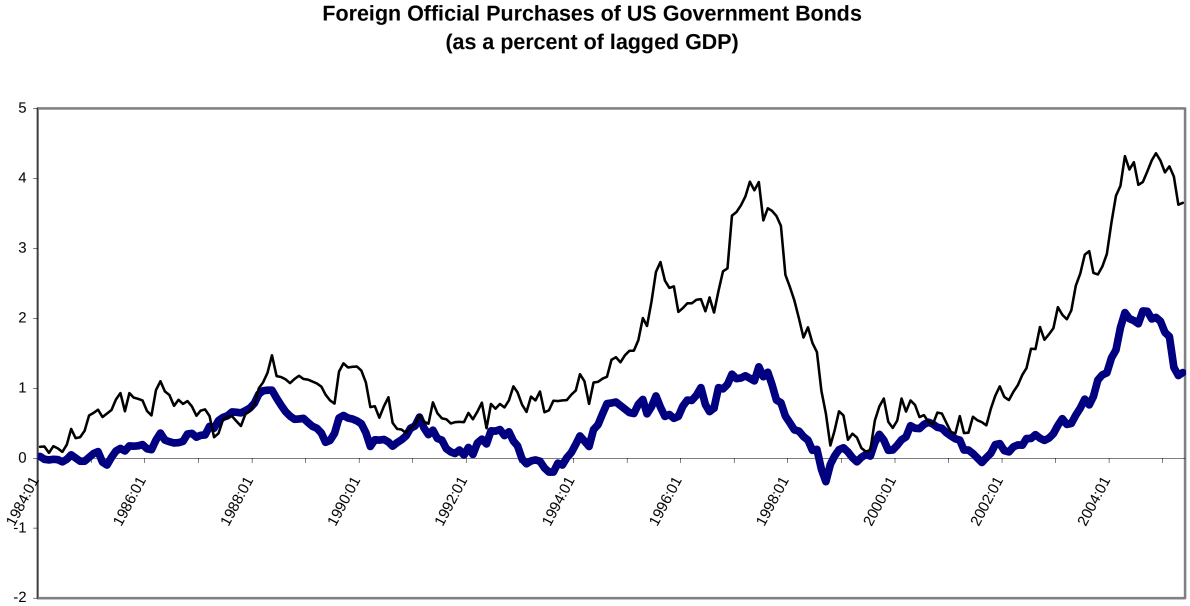
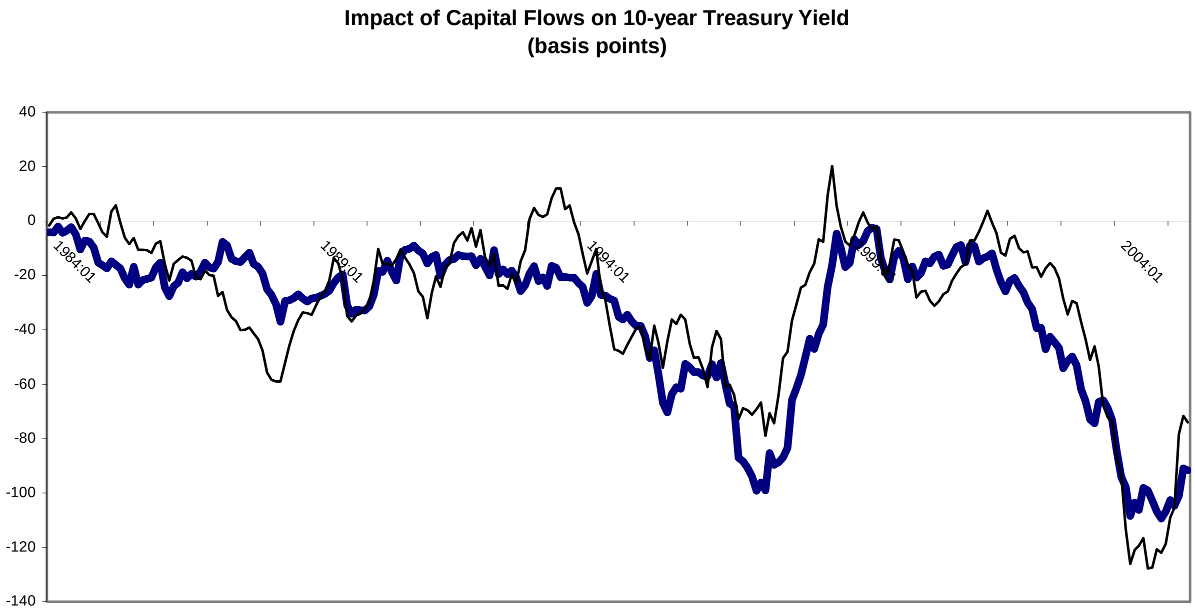


Figure 3: Impact of Foreign Flows into US Bonds on 10-year Treasury Yields

(a) Impact is calculated from the coefficient estimates in Columns 1 (thick line) and 2 (thin line) of Table 2.



(b) Fitted values (thin line) are calculated from the regression in Column 1 of Table 2.

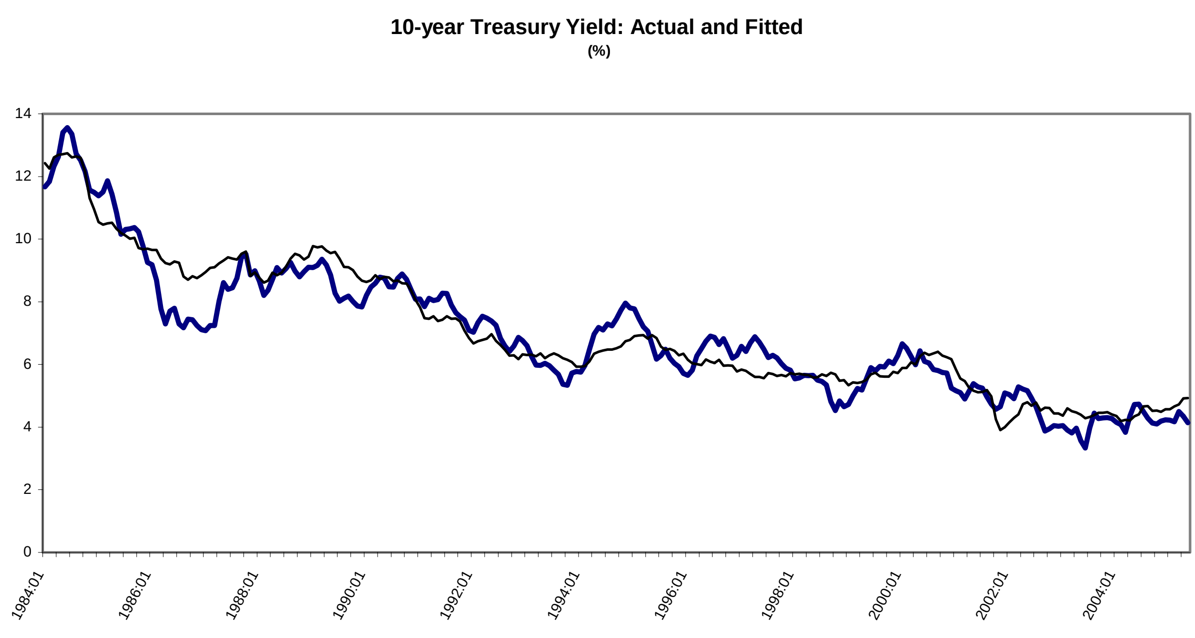
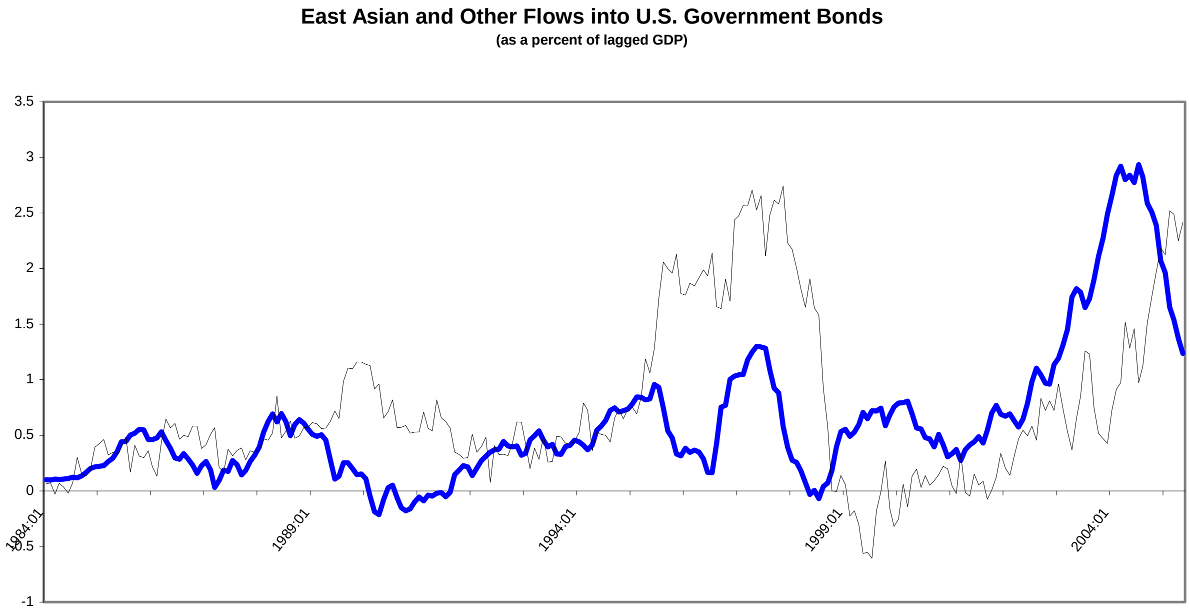
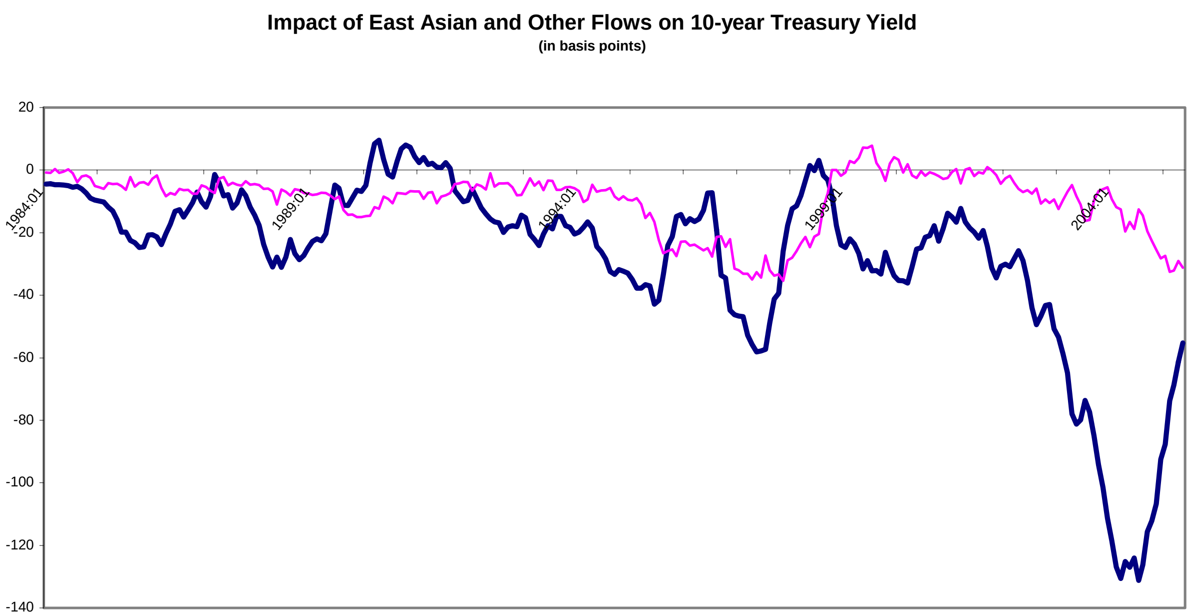


Figure 4: Decomposition of Foreign Flows

(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.

Figure A1. TIC-based Estimates of Foreign Positions in U.S. Bonds

TIC-based estimates start from benchmark survey amounts, shown by the large circles, and are formed by applying equation (A1); see the appendix for details. 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.