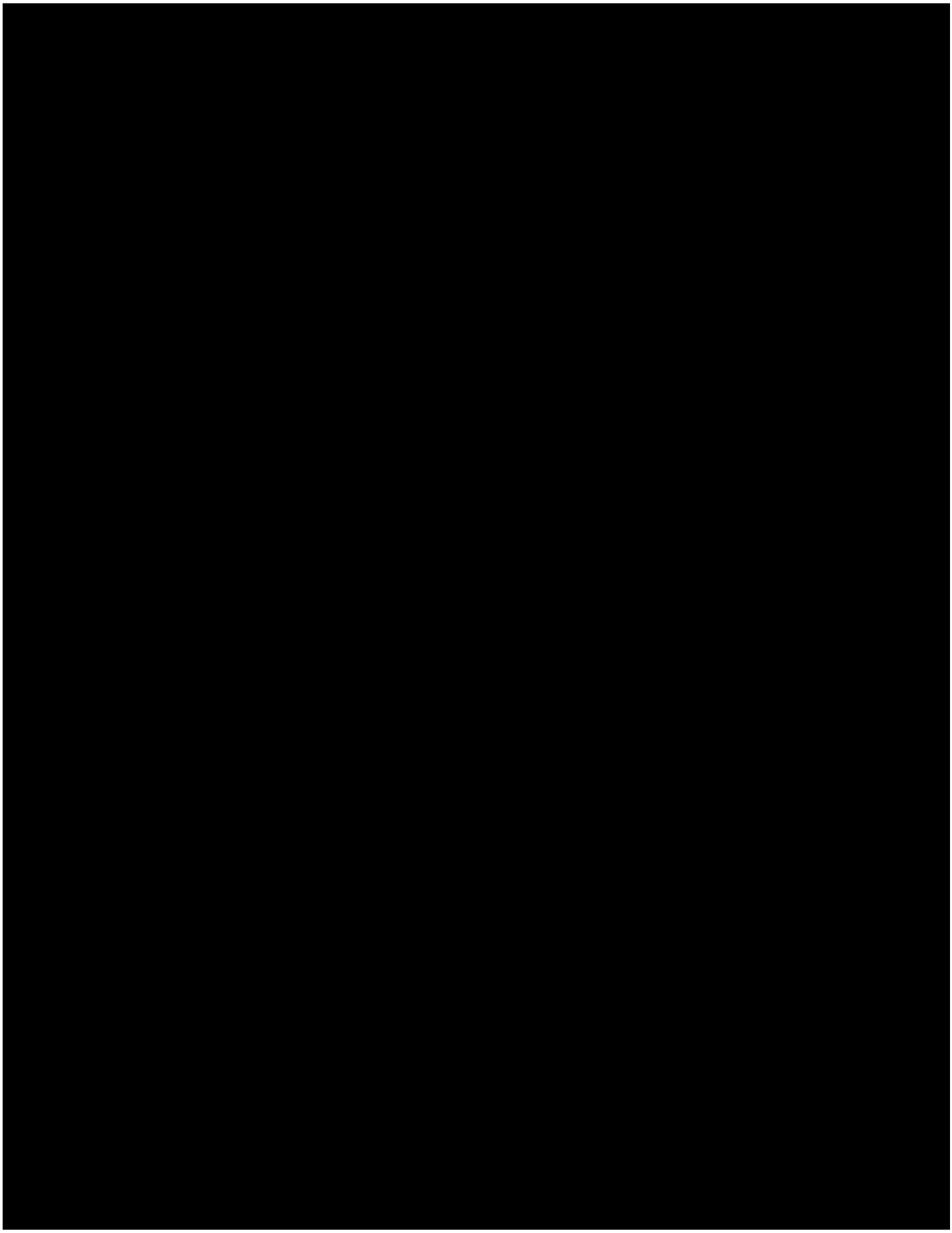

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# Uphill Capital Flows and the International Monetary System[†]

**Prepared by Balazs Csonto and Camilo E. Tovar**

Authorized for distribution by Kristina Kostial

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## Abstract

Uphill capital flows constitute a key transmission channel through which reserve accumulation can distort the stability of the international monetary system. This paper examines and quantifies the importance of this transmission channel by examining how foreign official purchases of U.S. Treasuries influences the U.S. yield curve at different maturities. Our findings suggest that a percentage point increase in foreign official holdings relative to outstanding marketable securities reduces the term premium by 2.0–2.4 basis points at maturities of 2–3 years. These estimates are then used to gauge the role of a global policy in reducing excess reserve accumulation—e.g., a composite global reserve asset or through global liquidity facilities. Findings show that a policy that reduces the demand for Treasuries by $100 billion would increase yields by 1.5–1.8 basis points.

JEL Classification Numbers: E43, E44, E58, F38, F42, F55, F62, G15

Keywords: Uphill capital flows, yield curve, term premium, U.S. Treasuries, reserve accumulation, foreign holdings

Author's E-Mail Address: bcsonto@imf.org; ctovar@imf.org

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## I. INTRODUCTION

Over the past two decades, emerging market economies (EMEs) have become increasingly interconnected and integrated with the global economy. This has facilitated an increasing flow of capital from developed to emerging economies—i.e., downhill capital flows— and, with it, to a rapid and unprecedented accumulation of international reserves (IMF, 2016a,b). However, this process reflects that changes and imbalances in the international monetary system—henceforth IMS (e.g., excessive build up of financial risks, spillovers from policies in advanced economies, inadequate global financial safety net)[1] have had side effects: the accumulated international reserves have found their way back into developed economies through the purchase of safe assets, such as U.S. securities. This phenomenon, hereafter referred to as *uphill capital flows*,[2] challenges the prediction of standard economic theory, which suggests that capital should flow from slow-growing developed countries to fast-growing developing countries.[3]

In this paper, we argue that uphill capital flows constitute a key *transmission channel* through which the imbalances between the demand and supply of international reserves influence the (IMS). For example, uphill capital flows associated with reserve accumulation in emerging and developing countries can influence financing costs in reserve-issuing countries (IMF, 2011a). This in turn can have domestic repercussions in advanced economies, as well as on the global economy, as it can distort consumption and investment decisions (both public and private), affect risk-taking, and trigger financial spillovers. Moreover, uphill capital flows can contribute to the buildup of global imbalances or to the *excess financial elasticity* displayed by the system by influencing domestic policy setting across the world (Borio, 2014).

Evidence accumulated over the past two decades has increasingly shown that the U.S. Treasuries market and the monetary transmission of U.S. monetary policy are susceptible of influence by uphill capital flows. In the early 2000s, for instance, Federal Reserve Chairman Alan Greenspan argued that the lack of response of the long end of the yield curve to the tightening of the U.S. Federal Reserve's policy rate was a *conundrum*. While different hypotheses were raised to explain the phenomenon, Bernanke (2005) suggested that this was the result of a *global saving glut* and of the need for EMEs to build *war chests* of foreign reserves to avoid future crises. In other words, these arguments made evident that reserve accumulation had found its way into U.S. Treasuries, thereby distorting the conduct of monetary policy in the U.S. and, more generally, global financing conditions.

The advent of the global financial crisis (GFC) in 2008 also raised concerns about uphill capital flows. However, the nature of the debate was somewhat different. Specifically, the

[1] See discussions in IMF (2016a, 2011b) and Prasad (2014).

[2] In this paper the term uphill capital flows is used loosely to refer to official flows that result from reserve accumulation. Nonetheless, uphill capital flows includes other components such as private capital flows.

[3] This paradox was first pointed out by Lucas (1990) and has been widely discussed since then (see, for example, Gourinchas and Jeanne, 2007 and Boz et al, 2017).

spillover effects of unconventional monetary policies (UMPs) in advanced economies triggered foreign exchange interventions in EMEs, with the resulting reserve accumulation leading to rising foreign official holdings of U.S. Treasuries. This pointed to U.S. policies generating spillbacks, thereby amplifying the global financial and economic cycle.

More recently, concerns about the impact of a reversal of uphill capital flows on U.S. yields became apparent as the U.S. Federal Reserve prepared and implemented the lift-off of interest rates. This was evident first in mid-2013, with the *Taper tantrum* episode, which generated expectations of capital flow reversals in EMEs and in parallel a retreat of official foreign holdings of the U.S. Treasuries. More recently, these concerns have resurfaced as the U.S. Federal Reserve Funds rate started to raise interest rates (Box 1and Boz et al., 2017).

Against this background, this paper quantifies the economic importance of uphill capital flows as a transmission channel that influences the stability and smooth operation of the IMS. This is done by estimating the impact of foreign official purchases of U.S. Treasury securities on the U.S. yield curve. The emphasis on U.S. Treasuries is explained by the predominant role of the U.S. dollar in the IMS. The dollar is currently the most widely used and traded currency in the world (IMF, 2015 a,b) and is the dominant international vehicle currency as it is present in 88 percent of global currency trades (BIS, 2016). These features together with the U.S. institutional set up and credibility of its policy frameworks make of the U.S. Treasuries market the largest and most liquid official market in the world, and the main source of global safe assets.[4] As a result, U.S. Treasuries have become global benchmarks for risk-free interest rates that underpin the pricing of other securities and many financial instruments in the U.S. and across the world (Fleming, 2000). U.S. Treasuries are also a key driver of global real interest rates (Hördahl et al., 2016), and a key variable influencing currency valuations and their influence across the world (Tovar and Mohd Nor, 2017). Few assets, if any, have the same global importance as that played by the U.S. Treasuries.[5] The paper also examines the extent to which uphill capital flows provide a rationale for a global policy aimed at reducing the accumulation of international reserves, for instance, through a global composite asset or the introduction of new global financing liquidity facilities.

The paper is organized as follows. Section II provides a context of the size of uphill capital flows to the U.S. and examines trends on U.S. Treasury yields and term premiums. Section III presents the econometric framework employed to quantify the impact of official foreign holdings of U.S. Treasuries on the yield curve and discusses the results. Section IV discusses possible options to mitigate weaknesses of the IMS associated with uphill capital flows. Section V concludes, exploring in particular the implications of the analysis for a global policy that were to induce a reduction of global excess demand for reserves.

[4] This notion, however, has been increasingly challenged. In particular, the global financial crisis showed that this characteristic depends on the soundness of the sovereign as well as of its financial sector, as these are closely interconnected.

[5] Agency debt, corporate debt, and interest-rate swaps could be considered alternatives but not fully (see, for example, agency debt during the global crisis, or the scandal surrounding the LIBOR rate). Moreover, the corporate market's potential is limited as the market is fragmented. Globally, the euro, the main competitor of the U.S. dollar, does not have a Eurozone bond market, leaving the German Bunds as the closest alternative to U.S. Treasuries, but without its scale.

## Box 1. U.S. Treasuries and the Global Policy Debate

This box provides a brief overview of how the global policy debate has been interlinked with the market for U.S. Treasuries.

**Greenspan's conundrum and the global savings glut**

In the early 2000s, economists were puzzled by the lack of response displayed by the long end of the yield curve to the tightening of the U.S. Federal Reserve's policy rate. According to U.S. Federal Reserve Chairman, Alan Greenspan, this decoupling—at least relative to previous tightening episodes of monetary policy — was a *conundrum* (Greenspan, 2005). While several explanations surfaced, one received ample attention. Ben Bernanke argued that the unresponsiveness of the U.S. yield curve to monetary policy had its origins in the IMS, in particular, in EMEs and their strategies for managing capital flows (Bernanke, 2005). In Bernanke's view, a combination of forces created a significant increase in global savings—a *global saving glut*—that explained both the increase in the U.S. current account deficit and the relatively low level of long-term real interest rates in the world. Moreover, he argued that EMEs' need to build *war chests* of foreign reserves to avoid future crises were behind a remarkable reversal in the flows of credit to developing countries and EMEs. That is, the sharp increase in global foreign exchange reserves in emerging and developing economies had found their way into U.S. Treasuries and other asset markets, depressing U.S. long-term interest rates.

**Unconventional monetary policies and currency wars**

The advent of the GFC brought to the fore the spillover effects of UMPs in advanced economies to the rest of the world. UMPs—i.e., the use of central bank balance sheets to implement expansionary policies through asset purchases and the use of forward guidance about the path of future interest rates—were meant to influence the term structure of interest rates by lowering the yields at longer maturities through the term premium. However, lower yields associated with these policies had spillover effects. They resulted in a search-for-yield process by investors, greater risk-taking by economic agents, an expansion of global liquidity conditions, and massive capital flows to EMEs. This dynamic was quite evident in 2010, following the announcement by the U.S. Federal Reserve regarding the second large-scale asset purchase program (LSAP) or Quantitative Easing (QE) 2. The LSAP not only redirected resources to bonds and stock markets in advanced economies, but also led to a search-for-yield behavior that stretched valuations, triggered investments in high-yield corporate bonds, and an explosion in sovereign and corporate debt across EMEs.

The massive capital flows to EMEs associated with UMPs contributed to the mispricing of assets—in particular, exchange rates—, and a renewed buildup of excess reserves. During this period many EMEs responded with the adoption of macroprudential policies, strong interventions in the foreign exchange (FX) market to lean against the wind, and therefore a massive accumulation of international reserves. This environment motivated Brazil's Finance Minister Guido Mantega to warn about the outbreak of international "currency wars" as governments across the world competed to lower their exchange rates to boost competitiveness. While there is no question that reserve accumulation during this period aimed at preventing rapid and excessive competitive losses, reserve accumulation associated with FX intervention also reflected concerns about the excessive volatility of capital flows or financial stability concerns about a potential reversal of capital flows.

Once again, the excess accumulation of international reserves in EMEs found their way back to the United States. In particular, much of the proceeds from FX interventions in emerging and developing countries were invested back into U.S. Treasury securities. Against this backdrop, a key question is whether FX intervention policies in EMEs had spillbacks effects on the U.S. economy and, in particular, on the U.S. yield curve.

**Monetary policy lift-off**

More recently, the timing and pace of the lift-off of interest rates in advanced economies, the Fed Funds rate and its potential spillover and spillback effects made evident the risk of downhill capital flows. Over the past decade, foreign official holdings of U.S. Treasuries expanded significantly that has increased the potential impact of a reversal as the Fed starts a tightening cycle. The question now is whether central banks will use the *war chest* built up over the past two decades, and if so how this would affect financing conditions in the U.S. and the IMS. In particular, the current discussion makes evident that excess reserve accumulation can influence the adjustment and stability of the IMS excess reserves are built up, but also as reserves are totally or partly drawdown. Moreover, it becomes evident that the mechanism has the potential to have asymmetric effects over the reserve accumulation cycle—with a larger amplification mechanism during the buildup, and a smaller one during the drawdown.

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1/ Alternative explanations to Greenspan's conundrum included the view that the bond market overshot due to the very low risk associated with the secular decline in inflation and low output volatility (i.e. the *Great Moderation*), or alternatively that the growth outlook was weaker than the consensus forecast, thus inducing the bond market to discount before slower growth manifests. Others argued that the emergence of new agents in the market, such as pension funds, increased the demand for long-term assets.

2/ See IMF (2013) for an overview of the recent experience with UMPs.

## II. STYLIZED FACTS ABOUT THE U.S. YIELD CURVE

The economic importance of uphill capital flows as a transmission channel influencing the stability and smooth operation of the IMS hinges on the extent to which these flows influence the U.S. Treasuries are market. Hence in this section, we provide a brief overview of trends in the demand for and supply of U.S. Treasuries, which put into perspective the importance of uphill capital flows. We also discuss some long-term trends on U.S. treasury yields and examine the term premium, which reflects the importance of the uphill capital flow transmission mechanism. Finally, we provide an overview of the literature examining the impact of foreign official purchases on U.S. treasury yields.

### A. Supply and Demand for Treasuries

U.S. Treasury public debt is held by domestic and foreign holders, and private and official holders. Formally,

$$T_{TOT} = T_D + T_F = \left(T_{D,P} + T_{D,O}\right) + \left(T_{F,P} + T_{F,O}\right) \qquad (1)$$

where $T_{TOT}$ is the total supply of Treasury debt, available for domestic $(D)$ or foreign $(F)$ as well as private $(P)$ or $(O)$ official investors.[6] Changes in the relative supply of U.S. Treasury securities available for the public can thus be driven by either domestic or foreign official purchases. These foreign official purchases are the corresponding measure of *uphill capital flows* that are of interest in this paper.

The motives and objectives of the demand for Treasuries varies across economic agents. For example, while the U.S. Federal Reserve relies on Treasuries for its operations and for achieving its policy objectives, foreign official and private investors tend to seek in the Treasury market, a highly liquid and safe asset to fulfill a store of value function as well as a means of exchange for conducting and hedging international transactions. At the same time, within these groups of investors the demand for Treasuries may be driven by very different purposes within these groups of investors. Official holders such as central banks usually rely on Treasuries to secure dollars for foreign exchange intervention purposes, while private investors might seek the safety of Treasuries in times of uncertainty.

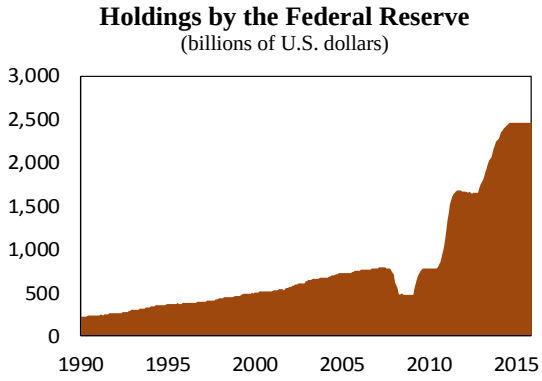
**Domestic official holdings of U.S. Treasury securities**

Domestic official holdings ($T_{D,O}$), i.e. those held by the U.S. Federal Reserve, have gained prominence since the GFC. Specifically, they accounted for about 10 percent of total outstanding marketable U.S. Treasuries for most part of the 1990s and early 2000s. However, the Federal Reserve implemented a number of quantitative easing measures in the form of LSAPs between 2008 and 2012—when the policy rate hit the zero lower bound. As a result, the Federal Reserve's holdings of Treasury securities increased from US$ 500 billion at end-2008 to US$ 2.5 trillion by end-2014 (Figure 1). These LSAPs included the purchase of U.S.

[6] For a discussion in a similar context see *Kitchen and Chinn* (2011).

Treasury securities in the size of US$ 300 billion in 2009 (QE1), US$ 600 billion between the end of 2010 and mid-2011 (QE2) as well as almost US$ 800 billion between end-2012 and 2014 (QE3). Moreover, the composition of holdings shifted toward longer maturities, as the maturity extension program included the purchase of US$ 400 billion of securities with maturity of 6 to 30 years and the sale of an equal amount of securities with maturity of 3 years and less in 2011–12 (Operation Twist).[7]

**Figure 1. Domestic Official Holdings of U.S. Treasury Securities**




Source: Federal Reserve Board.

**Foreign official holdings of U.S. Treasury securities**

Foreign official holdings ($T_{F,O}$) of U.S. Treasuries have gained prominence, in particular, since the early 2000s. Indeed, they increased from negligible levels in the early 1990s to slightly over US$ 600 billion (around 27 percent of total marketable Treasury securities) by the end of the 1990s. Since then they have experienced a sustained increase, reaching nearly US$4 trillion (above 40 percent of total marketable Treasury debt securities) in recent years (Figure 2).

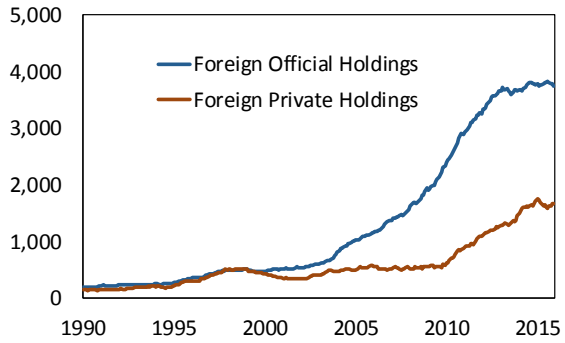
The increase in foreign official holdings of U.S. Treasuries since the early 2000s has taken place in two large waves. These have been driven first by precautionary reserve accumulation, investments by commodity exporters driven by high commodity prices and/or exchange rate policy motives in the pre-GFC period, and then by foreign exchange interventions undertaken as a response to spillovers (e.g., surging capital inflows) arising from UMPs in advanced economies during the GFC:

In the *first wave*, global official foreign exchange reserves increased more than threefold between the early 2000s and the onset of the GFC, reaching US$ 7.5 trillion by mid-2008. The increase was mainly driven by EMEs, in particularly China, Korea, India, Malaysia, Russia and the oil-exporting countries (IMF, 2016; Mohanty and Turner, 2006). Specifically, EMEs accumulated reserves at an annual rate of over US$ 700 billion between 2003 and

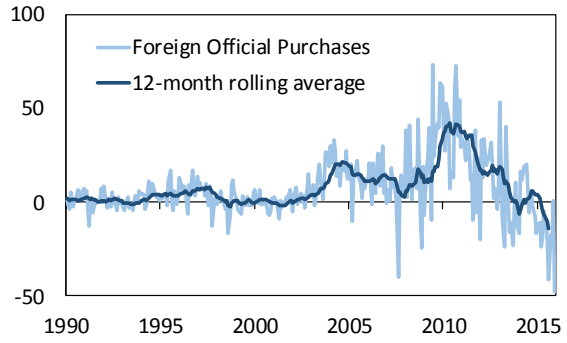
[7] See Annex I. for more details.

## Figure 2. Foreign Official Holdings of U.S. Treasury Securities

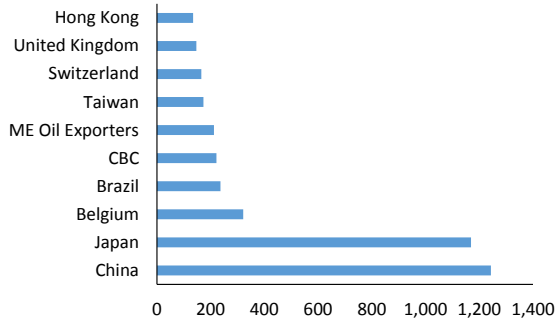
**Holdings of U.S. Treasury Securities by Investor Type** (billions of U.S. dollars)



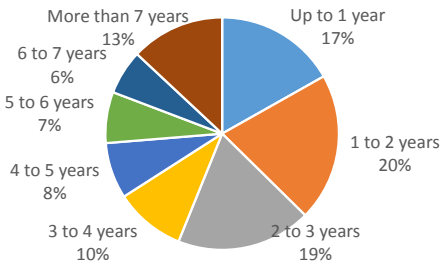

**Foreign Official Purchases of U.S. Treasury Securities** (billions of U.S. dollars)




**Major Foreign Holders of U.S. Treasury Securities, end-2014** (billions of U.S. dollars)




**Remaining Maturity Structure of Foreign Official Holdings of Long-Term U.S. Treasury Securities, June 30, 2014**




Source: TIC, Bertaut and Tyron (2007), Bertaud and Judson (2014), Authors' calculations.

Note: CBC and ME Oil Exporters stand for Caribbean Banking Centers (Bonaire, St. Eustatius and Saba, Bahamas, Bermuda, Cayman Islands, Curacao, Sint Maarten, and Panama) and Middle East Oil Exporters (Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates), respectively.

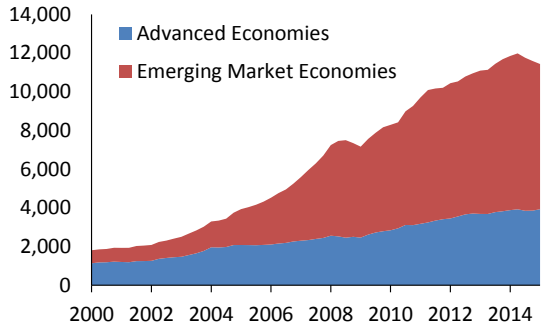
2008. Moreover, official reserves have been concentrated in a single currency, with U.S. dollar-denominated assets constituting about 65 percent of allocated reserves at the start of the GFC—albeit somewhat lower than their share of 70 percent in 2000 (Figure 3). As a result, foreign official holdings of U.S. Treasury securities also increased substantially from around US$ 600 billion in 2003 (17 percent of marketable securities) to US$ 1.7 trillion (34 percent of marketable securities) in mid-2008.

In the *second wave*, global official reserves increased further by US$ 4 trillion between 2009 and 2014 as a large number of countries resorted to foreign exchange interventions in the face of surging capital inflows during the GFC. The build-up of reserves continued to be driven by EMEs that accumulated reserves at an annual rate of US$ 600 billion during this period. As a result, foreign official holdings of U.S. Treasury securities almost doubled between mid-2009 and the end of 2014. However, they remained broadly stable relative to total outstanding marketable securities. The increase was the most pronounced in 2009 and 2010 when annual foreign official flows to U.S. Treasury securities exceeded US$ 400

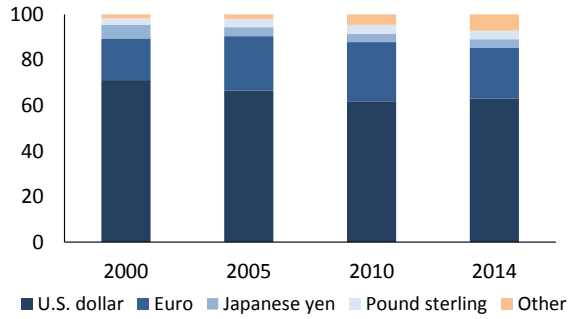
billion (Figure 3). This surge coincides with the first two LSAPs undertaken by the Federal Reserve. Indeed, EMEs expressed their concerns about spillovers from UMPs, including exchange rate pressures arising from surging capital inflows (Chutasripanich and Yetman, 2015).

**Figure 3. Foreign Exchange Reserves and its Currency Breakdown**

**Official Foreign Exchange Reserves**
(billions of U.S. dollar)




**Currency Composition of Global Official Foreign Exchange Reserves** (percent)




Source: COFER, Authors' calculations.

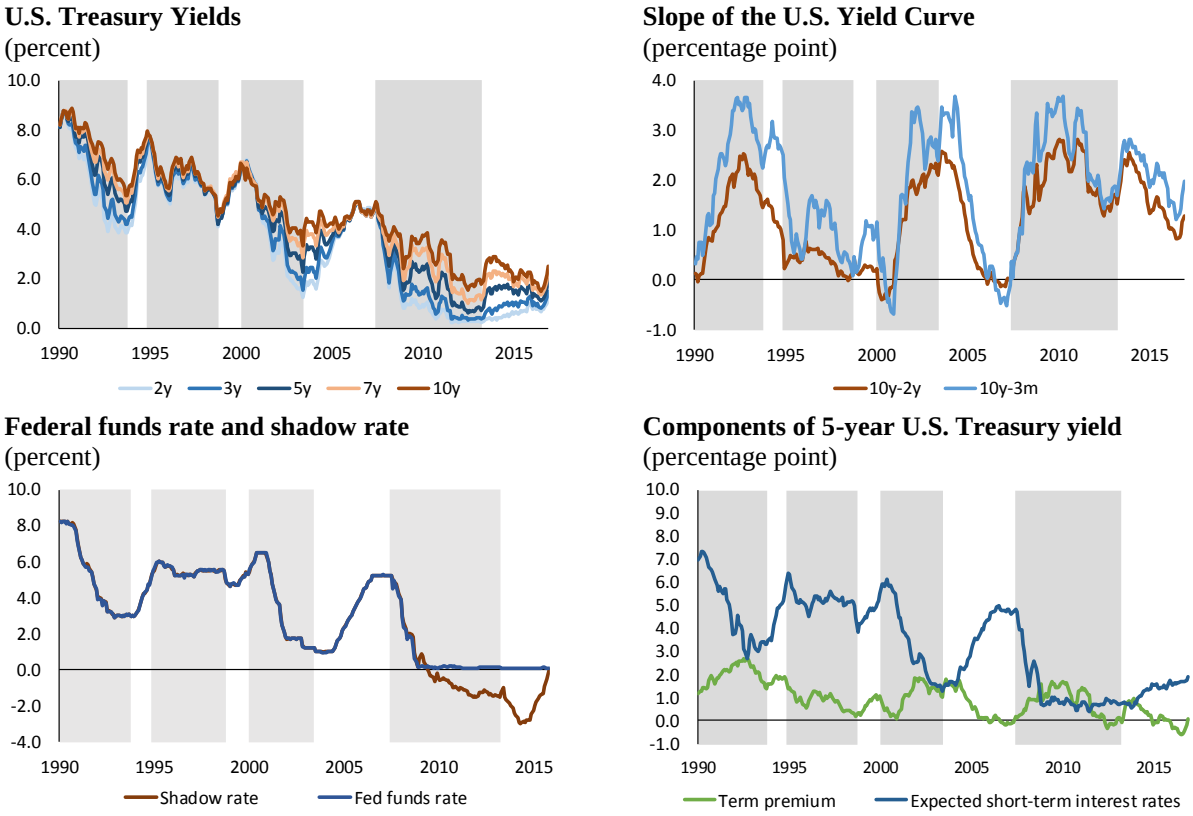
## B. Long-Term Interest Rates and the Term Premium

Long-term interest rates have experienced a downward trend during the last two decades (Figure 4). For example, the 5-year U.S. Treasury yield—the most liquid maturity—fell from over 8 percent in the early 1990s to under 2 percent in the more recent years.[8] While the downward trend is evident, there have been four episodes associated with a sharp decline in yields: the early 1990s, the second half of the 1990s, the early 2000s, and, the late 2000s, coinciding with the GFC and later characterized by the Fed funds rate hitting the zero lower bound.[9] All episodes, except the one in the second half of the 1990s—which included the dotcom bubble and experienced an inverted yield curve—share a number of similarities: (i) they all coincided with episodes of monetary easing by the Federal Reserve with the Fed Funds rates being cut by about 400 bps; (ii) an increasingslope of U.S. Treasury yield curve; (ii) a decline in expected short-term interest rates, driving the decline of long-term yields; and, (iv) a transitory widening of the term premium.

[8] Traditionally, the 2-year maturity was the most liquid (measured by daily turnover) segment of the U.S. Treasury market. However, the daily turnover for the 2-year securities has declined since 2008, with 5-year Treasuries becoming the most liquid segment of the market. This shift likely reflects the sustained levels of low interest rates since the onset of the GFC (Adrian, 2013).

[9] In a zero-lower bound environment, the shadow rate can characterize both the term structure of interest rates and the stance of monetary policy (See Figure 4, bottom left panel).

**Figure 4. U.S. Treasury Yield Dynamics and the Federal Funds Rate**

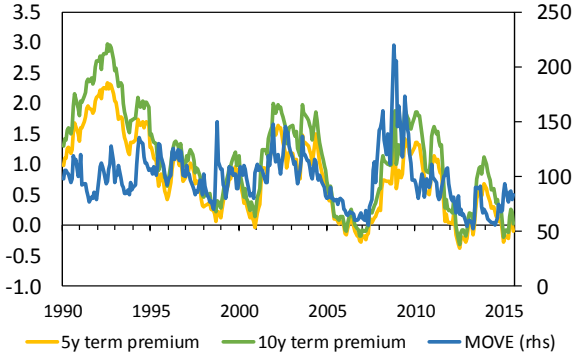



Source: FRB, Adrian et al. (2013), Wu and Xia (2014).
Note: Shaded areas display periods of sustained declines in U.S. Treasuries.

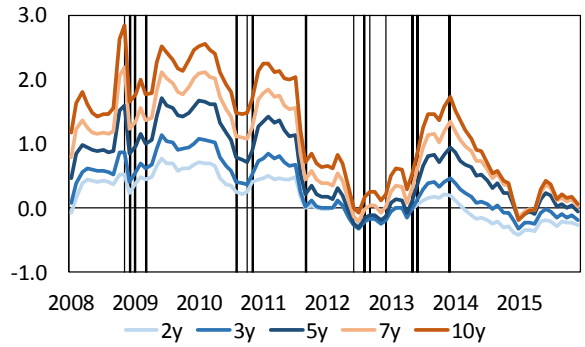
The evolution of the term premium is the least systemic factor driving yields of U.S. securities (bottom right-panel of Figure 4). Although non-observable, it can be estimated from data on short- and long-term interest rates (Adrian et al., 2014 and 2013). Evidence suggests that it is driven by changes in risk perception and changes in the relative supply of securities (Bernanke, 2015). Specifically, the term premium increases with risk aversion—i.e. rising risk perception associated with longer-term securities—, and with uncertainty about the future path of interest rates. This is confirmed in Figure 5, which shows that the 10-year U.S. Treasury term premium exhibits a strong positive correlation with bond market volatility, as measured by the Merrill Lynch Option Volatility Estimate (MOVE) Index (Adrian et al. 2013 and Wu 2014).

**Figure 5. Term Premia, Risk Perception, and UMP**

**Term Premia on U.S. Treasury Securities and Risk Perception**




**Term Premium on Long-Term U.S. Treasury Securities and UMP Announcements** (percent)




Source: Federal Reserve Board, Adrian et al. (2013).
Note: QE, OT, and TT stand for quantitative easing, operation twist and taper tantrum, respectively. The vertical lines depict policy decisions, announcements, and the start of the program for each of these episodes. See Annex 1 for a detailed description.

## C. How Do Foreign Official Purchases Affect U.S. Treasuries: An Overview of the Literature

The extent to which foreign official holdings of U.S. Treasury securities have affected yields is somewhat mixed.[10] While few studies suggest that yields are unrelated to foreign U.S. Treasuries purchases (Rudebusch et al., 2006), the evidence—which mostly focuses on the early 2000s—tends to support the notion that foreign official purchases lowers U.S. yields (Bernanke et al., 2004; McCauley and Jiang, 2004; Warnock and Warnock, 2005; Sierra, 2010; Beltran et al., 2013; and Wolcott, 2016).[11] There is also some evidence that their impact may be only temporary (McCauley and Jiang, 2004),[12] and that there may be spillover effects through global portfolio balance effects, thus allowing the decline in U.S. yields to pass through to other bond markets (Gerlach-Kristen et al., 2012). The evidence also suggests that the relationship might have changed over time. In particular, most studies covering the period closer to the GFC find a strong negative relationship between foreign official holdings and U.S. yields. For instance, Beltran et al. (2013) examined the period 1994–2007, and found that US$100 billion in foreign official inflows lowered the 5-year yield by 40 to 60 basis points in the short- and medium-run, and by 17–20 basis points in the long run. Sierra

[10] See Bernanke's global savings glut hypothesis and Greenspan's conundrum speech (*Bernanke*, 2005; *Greenspan*, 2005, respectively).

[11] Bernanke et al. (2004) find a negative relationship between foreign exchange interventions and U.S. Treasury yields. Specifically, they show that interventions undertaken by the Japanese Ministry of Finance between 2000 and 2004 could have lowered 10-year U.S. Treasury yields by 66 basis points for every purchase of US$ 100 billion.

[12] McCauley and Jiang (2004) find a significant negative relationship between weekly changes in 10-year U.S. Treasury yields and foreign official holdings, with the latter proxied by custodial holdings at the New York Federal Reserve, but only over two short periods in 2000 and 2003. Warnock and Warnock (2005) also found a negative relationship between the 10-year U.S. Treasury yield and foreign inflows between 1984 and 2005. According to their estimates, the presence of foreign investors in the U.S. Treasuries market lowered the 10-year yield by 150 bps between mid-2004 and mid-2005.

(2010) also founds that excess returns are negatively associated with foreign official purchases during this same period. He showed that the impact of foreign official flows gradually weakens for longer maturities (over 6 years). Few empirical studies, however, analyzed the impact of foreign holdings on yields during the GFC. An exception is Kaminska and Zinna (2014) who found a moderate impact of foreign official demand for U.S. Treasuries on long-term U.S. real rates during the GFC.

In contrast with conventional monetary policy tools that focus on the expectations channel, the quantitative easing programs aimed at lowering long-term interest rates through supply-demand effects, i.e. lowering the term premium by changing the relative supply of securities (Bernanke, 2011; Stein, 2012). The impact of these programs on long-term yields has been discussed widely in the literature. D'Amico and King (2010) found that the first LSAP lowered yields by around 30–35 basis points across the yield curve in 2009, with the effect being the most pronounced at maturities of 10–15 years, while D'Amico et al. (2012) showed that the second LSAP reduced long-term yields by about 45 basis points. Kaminska and Zinna (2014) found that purchases by the Federal Reserve lowered yields by around 140 basis points between 2009 and 2012. Using an event study analysis, Gagnon et al. (2011) find that LSAP announcements reduced the 10-year term premium by around 50-100 basis points.

It is important to highlight that the Fed's LSAP programs are likely to have a smaller effect on the term premium (Beltran et al., 2013). This is partly because LSAPs were designed to be part of a temporary stimulus program, while foreign purchases of Treasuries are perceived as more permanent. Moreover, LSAPs are likely to have an impact on the inflation risk premium, which is expected to be unaffected by foreign purchases. Finally, gauging the effects of LSAPs are complicated since some of its effects may have been anticipated by the markets.

## III. Uphill Capital Flows and the IMS: Quantifying the Impact of Foreign Official Purchases of U.S. Treasuries

To quantify how uphill capital flows affect the stability and smooth operation of the IMS, we study in this section the relationship between the term premium and foreign official holdings of U.S. Treasury securities. Long-term interest rates can be decomposed into three components: expectations about the future path of short-term real interest rates, expected inflation, and the term premium (See Annex 2). To the extent that foreign official holdings of U.S. securities do not affect the path of real interest rates and/or expected inflation, their impact on the shape of the yield curve will only operate through the risk or term premium variables. That is, analyzing the impact of foreign official purchases of U.S. Treasuries on the U.S. yield curve can be reduced to an analysis of its relationship with the term premium.[13]

[13] Foreign official holdings could affect the future path of short-term interest rates if foreign exchange interventions by foreign central banks have an impact on growth and inflation outlook in the United States. For example, interventions aimed at keeping the currency undervalued relative to the U.S. dollar could lower economic growth and inflation in the United States by hurting its competitiveness, thereby triggering looser monetary conditions and lower short-term interest rates. For the purposes of this study we assume that this channel is of second order.

Quantifying the relationship between foreign official holdings/purchases and U.S. Treasury yields raises a number of issues. For example, there can be an interdependency between treasury yields and foreign demand for Treasuries, which implies that the direction of causation operates in both directions. Although some studies treat foreign official demand as exogenous (Warnock and Warnock, 2005), reserve managers actually tend to reallocate their portfolios in response to changes in asset prices (Beltran et al., 2013). To address this endogeneity problem, the literature has followed two approaches: the use of instrumental variables (IV) (Sierra, 2010) or the use of multivariate frameworks such as vector-error correction models (VECMs) (Beltran et al., 2013). Moreover, the literature is divided on the measure of yields. While some papers use yield levels or changes (McCauley and Jiang, 2004), others analyze the impact on the estimated term premium or realized excess returns (Sierra, 2010; Beltran et al., 2013). This last approach emphasizes that foreign demand for U.S. Treasuries tends to influence yields through the term premium by altering the relative supply of securities. Using the term premium also addresses possible biases arising from long-term interest being influenced by (non-observable) forward-looking expectations (e.g., monetary policy stance). The econometric approach thus follows that used by Beltran et al. (2013).

## A. Econometric Framework

The estimated econometric model is a vector error correction model. This econometric approach addresses the endogeneity problem between the term premium and foreign holdings of U.S. Treasury securities, and allows to examine both the long-run and short-run dynamics between changes in the term premium and foreign holdings of U.S. Treasury securities. Formally, the VECM is of the following type:

$$\Delta Z_t = \sum_{k=1}^{n} \Gamma_k \Delta Z_{t-k} + \Pi Z_t + \varepsilon_t \qquad (2)$$

Where in our baseline specification $Z \equiv [\rho_m \quad T_{F,O} \;\; T_{FED} \quad \upsilon \;]'$ is $(4\times1)$ vector of endogenous regressors; $\rho_m$ is the term premium and $m$ denotes the corresponding maturity (2, 3, 5, 7, or 10 years), $\upsilon$ is a proxy for uncertainty as captured by the MOVE Index, $T_{F,O}$ and $T_{FED}$ are holdings by foreign officials and the Federal Reserve, respectively, and k is the number of lags in the VECM. $\Pi = \alpha\beta'$ where α and β are $(4\times1)$ matrices that measure the speed of adjustment to equilibrium and the long-run cointegration relationship, respectively. Γ is a matrix that summarizes the short-run dynamics of the model. Finally, the error term is $\varepsilon_t \sim IN(0, \Omega_{4\times4})$. Since foreign private investors could react endogenously to yield changes induced by shocks to foreign official holdings, as a robustness check, the model is also estimated including both foreign official and private holdings of U.S. Treasuries.[14]

[14] However, Sierra (2010) shows that the impact of official and private flows differs: while official flows are similar to relative supply shocks, private flows seem to absorb excess supply.

## B. Sample and Data

The model is estimated over for the period January 2003 to December 2015. The focus on this sample period is related to the surge in foreign holdings of U.S. Treasury securities starting in 2003 (Figure 2, upper-left panel). The dependent variable in the analysis are monthly average term premium estimates for maturities of 2, 3, 5, 7 and 10 years as displayed in Figure 5. These estimates are obtained from a five-factor, no-arbitrage term structure model using zero-coupon yields from Gurkaynak et al. (2006) as reported by the Federal Reserve Bank of New York (Adrian et al. (2013). Foreign holdings are normalized relative to the total stock outstanding.

We use monthly data on *foreign official holdings of U.S. Treasury securities* as provided by Bertaut and Tyron (2007) until June 2011 and by Bertaud and Judson (2014) for the period between June 2011 and December 2014. The former estimates monthly foreign holdings by combining annual survey data of the Treasury International Capital (TIC) system on securities holdings with monthly transactions data from the TIC S form, while the later combine information from the annual survey with monthly holdings from the TIC SLT form.[15] In general, monthly holdings are estimated as the sum of the latest annual survey data and cumulative transactions (TIC S) or changes in monthly holdings (TIC SLT).[16] Estimated monthly positions are then corrected when the following year's annual survey data become available. The econometric analysis normalizes foreign holdings by the outstanding stock of marketable Treasury securities.

Data on *holdings of U.S. Treasury securities by the Federal Reserve* were obtained from the FRED database of the Federal Reserve Bank of St. Louis. In a similar fashion to foreign holdings, domestic official holdings are normalized by the stock of marketable Treasury securities.

Finally, the *MOVE Index* serves as a proxy for bond market uncertainty. Specifically, it is a yield curve-weighted index of the normalized implied volatility on 1-month Treasury options on 2-, 5-, 10-, and 30-year securities. The source of the data is Bloomberg.

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[15] The annual surveys include information on foreign holdings of U.S. securities (stock) at the end of June every year. The TIC S data includes monthly cross-border transactions of securities (flow). The TIC SLT, introduced in 2011, collects data on foreign holdings of long-term securities (stock). While both the annual survey and the TIC SLT provide data on foreign holdings, the former is more detailed and comprehensive.

[16] The TIC S is prone to a number of biases, in particular the transaction and custodial bias. Specifically, given that the TIC S data are collected according to the country of the first cross-border counterparty, transactions are often concentrated in financial centers, causing a bias in their geographic distribution. Moreover, foreign private holdings could be overestimated relative to foreign official holdings (e.g., if an official investor holds U.S. securities with a foreign private custodian bank). As the TIC SLT collects information on actual holdings, it does not suffer from the transaction bias. However, it is also subject to the custodial bias that could distort both the geographic distribution (e.g., if a foreign holder has a custodian in a different country) and the size of foreign holdings (e.g., if a U.S. investor has a foreign custodian, foreign holdings of U.S. securities are overestimated).

## C. Econometric Results

The analysis employs Johansen's maximum likelihood cointegration analysis due to the existence of unit roots in the data.[17] Hence, the first step is to determine the number of lags to be included in the VECM. Both the Akaike's information Criteria (AIC) and Hannan and Quinn's information criterion (HQIC) suggest an optimal lag structure of 2 periods for all maturities (Annex 3). Second, it is necessary to obtain the number of long-run relations given by the rank of Π, using the trace and maximum eigenvalue tests. Both the maximum eigenvalue test[18] and the trace test[19] suggest the presence of one cointegration relationship for each maturity (Annex 3).

The baseline specification suggests that foreign official and Federal Reserve holdings of U.S. Treasury securities have a *negative* relationship with the term premium across all maturities. By contrast, the uncertainty parameter, measured by the MOVE index, is positively associated with the term premium—that is, the β component of Π in Eq. (2) as reported in Table 1. Specifically, the baseline specification suggests that *a one percentage point increase in foreign official holdings relative to outstanding marketable securities reduces the term premium by 2.0-2.4 basis points at maturities of 3 years or less.* In contrast with some previous empirical results in the literature, foreign official holdings do not have a significant relationship with the term premium at maturities of 5-10 years. However, this is not surprising given that foreign official holdings are concentrated at maturities of 3 years and less (Figure 4, bottom-right panel).

Federal Reserve holdings have a significant negative relationship with the term premium at every maturity. Moreover, the absolute value of its impact increases with the maturity of the market segment. Specifically, a one percentage point increase in Federal Reserve Holdings relative to marketable securities lowers the term premium by 2.6 basis points at 2-year and by 9.4 basis points at 10-year maturities. This behavior is in line with the prior that LSAPs aimed at reducing the long end of the yield curve. The MOVE index is highly significant at every maturity and, just as it happens with Federal Reserve holdings, its impact increases with the maturity.

The short-run adjustment parameter—the α component of Π in Eq. (2)—is significant for all maturities in the case of the term premium equation. According to our estimates, the adjustment to disequilibria in the long run relationship ranges from about 9 percent at the short end of the yield curve to 5.3 percent at the long end of the curve.[20]

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[17] Prior to the estimation of Eq. (2), we tested for the order of integration of $\rho_m$, $T_{F,O}$, $T_{FED}$, and $v$. The Dickey-Fuller, augmented Dickey-Fuller and Phillips-Perron tests are not able to reject the null hypothesis of unit roots for any of these series.

[18] The likelihood-ratio tests the null hypothesis of exactly $r$ cointegration relationships versus the alternative of $r + 1$.

[19] Where the null hypothesis is that there are no more than r cointegration relationships.

[20] The Jarque-Bera normality test rejects the null hypothesis that the residuals from the term premium equation are normally distributed (Table 2). However, in the case of lower maturities this is mainly due to kurtosis rather than to skewness. As *Paruolo* (1997) has shown, if the rejection of normality is driven by kurtosis rather than skewness, the Johansen cointegration results are unaffected. This allows us to conclude that the fit of our model is adequate.

**Table 1. Baseline Term Premium Equation**
(Cointegration Vectors, Loading Factors, and Normality Tests)

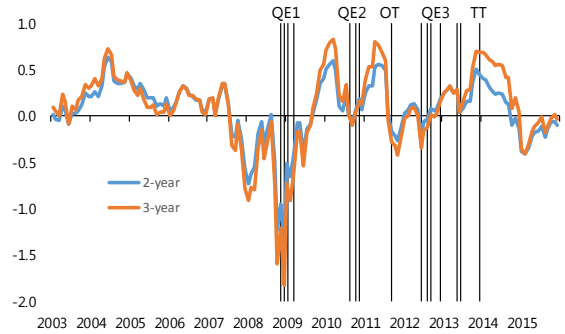
| | 2-year | 3-year | 5-year | 7-year | 10-year | Memo: Sample average (US$) |
|---|---|---|---|---|---|---|
| **Cointegration Vector (β)** | 1 | 1 | 1 | 1 | 1 | |
| Foreign Official Holdings | 0.019 ** | 0.024 ** | 0.023 | 0.018 | 0.012 | *28.62* |
| | (0.007) | (0.010) | (0.017) | (0.021) | (0.024) | |
| Federal Reserve Holdings | 0.026 ** | 0.033 ** | 0.057 ** | 0.076 *** | 0.094 *** | *15.20* |
| | (0.010) | (0.014) | (0.023) | (0.029) | (0.033) | |
| MOVE | -0.012 *** | -0.016 *** | -0.022 *** | -0.026 *** | -0.030 *** | *93.10* |
| | (0.001) | (0.002) | (0.003) | (0.004) | (0.004) | |
| **Loading Factor (α)** | -0.087 *** | -0.080 *** | -0.065 *** | -0.060 *** | -0.057 ** | |
| | (0.023) | (0.023) | (0.022) | (0.021) | (0.021) | |
| ***Normality Tests*** | | | | | | |
| Jarque-Bera | 62.01 *** | 91.64 *** | 191.50 *** | 340.85 *** | 546.77 *** | |
| Skewness | 0.40 | 1.98 | 4.33 ** | 7.27 *** | 12.11 *** | |
| Kurtosis | 61.61 *** | 89.66 *** | 187.17 *** | 333.58 *** | 534.66 *** | |

Note: Each specification includes two lags. Standard errors in parenthesis. ***, ** and * indicate significance at 1, 5 and 10 percent, respectively.

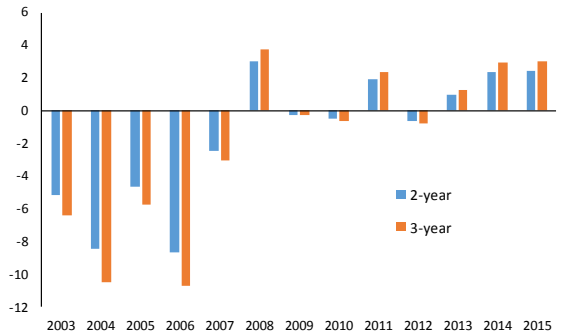
The long-term cointegration relationships suggest that the term premium was higher than justified by its determinants in the pre-crisis period as well as in the last few years (i.e., during the tapering period). At the same time, there is a large negative deviation from its long-run equilibrium value in 2009, coinciding with initial LSAP announcements (Figure 6, left-hand panel).

**Figure 6. Long-Term Disequilibrium and the Contribution of Foreign Official Holdings to Changes in the Term Premium**

**Long-Term Disequilibrium**
(percentage point)




**Contribution of Foreign Official Holdings to Changes in the Term Premium** (basis points)




Source: Authors' calculations.
Note: QE, OT and TT stand for quantitative easing, operation twist and taper tantrum, respectively. The vertical lines depict policy decisions, announcements, and the start of the program for each of these episodes. See Annex 1 for a detailed description.

### D. Robustness Analysis

Foreign private investors could react endogenously to yield changes induced by shocks to foreign official holdings. Hence as a robustness check, the model is also estimated including both foreign official and private holdings of U.S. Treasuries ( i.e. $Z_a \equiv [\rho \quad T_{F,O} \quad T_{F,P} \quad T_{FED,O} \quad \upsilon]'$). Foreign official holdings remain significant at short-term maturities, with broadly similar impact on the term premium as in the baseline specification. However, the long run coefficient of foreign private holdings is not significant across all maturities. Moreover, the coefficient of Federal Reserve holdings becomes insignificant (Table 2).

**Table 2. Robustness Analysis: Term Premium Equation**
(Cointegration Vectors, Loading Factors, and Normality Tests)

| | 2-year | 3-year | 5-year | 7-year | 10-year |
|---|---|---|---|---|---|
| Term Premium | 1 | 1 | 1 | 1 | 1 |
| Foreign Official Holdings | 0.019 ** | 0.022 ** | 0.021 | 0.018 | 0.015 |
| | (0.008) | (0.011) | (0.017) | (0.020) | (0.022) |
| Foreign Private Holdings | 0.042 | 0.034 | 0.026 | 0.053 | 0.116 |
| | (0.054) | (0.075) | (0.119) | (0.142) | (0.157) |
| Federal Reserve Holdings | 0.006 | 0.022 | 0.054 | 0.054 | 0.026 |
| | (0.029) | (0.042) | (0.066) | (0.079) | (0.087) |
| MOVE | -0.013 *** | -0.017 *** | -0.024 *** | -0.029 *** | -0.034 *** |
| | (0.002) | (0.002) | (0.004) | (0.005) | (0.005) |
| Loading Factor (Term Premium) | -0.075 *** | -0.065 *** | -0.051 ** | -0.047 ** | -0.045 ** |
| | (0.024) | (0.023) | (0.021) | (0.022) | (0.023) |
| Jarque-Bera test (Term Premium) | 59.57 *** | 83.87 *** | 165.64 *** | 287.86 *** | 451.54 *** |
| Skewness (Term Premium) | 0.94 | 2.94 * | 6.57 ** | 11.61 *** | 19.31 *** |
| Kurtosis (Term Premium) | 58.63 *** | 80.93 *** | 159.08 *** | 276.25 *** | 432.23 *** |

Note: Each specification includes two lags. Standard errors in parenthesis. ***, ** and * indicate significance at 1, 5 and 10 percent, respectively.

### E. Counterfactual Analysis: Assessing the Impact of Policies to Reduce the Excess Global Demand for Reserves

The estimated coefficients can be employed to quantify the contribution of foreign official purchases to the 2- and 3--year term premium. This is implemented using the baseline estimation and calculating the counterfactual evolution of the ratio of foreign official holdings to marketable securities in the absence of foreign purchases since 2003. That is,

with the aim of understanding the contribution of foreign official purchases to the term premium, it is possible to calculate the difference between the actual and counterfactual ratio of foreign holdings to marketable securities. Results for 2- and 3-year Treasuries show that foreign official demand reduced the term premium by around 5–11 basis points every year in the pre-crisis period. In other words, in the absence of foreign official purchases between 2003 and 2007 the term premium would have been 35–50 basis points higher (depending on the maturity) at the onset of the GFC. During the GFC, foreign official holdings had a lower impact on the term premium. Starting in 2013, with the taper, foreign official holdings increased the term premium by 2.5–3.3 basis points.

## IV. Some Policy Implications for the International Monetary System

The results obtained in the previous section can be used to simulate the impact of global policies aimed at reducing excess accumulation of international reserves and, hence, the demand for U.S. Treasuries.

Specifically, we consider a policy experiment aimed at reducing excess reserve accumulation through the use of a global composite reserve asset—for example, through an allocation of a global composite asset, such as the IMF's Special Drawing Rights (SDR),[21] or through the introduction of new global liquidity facilities if they either instrument were to reduce excess reserve accumulation —that results in a decrease in the demand for Treasuries of US$100 billion (i.e., a reduction in the demand for marketable securities equal to 0.74 percent of the stock of marketable U.S. Treasuries as of December 2015). This would trigger an increase of 1.5 and 1.8 basis points in U.S. Treasuries yields of 2- and 3-year maturities, respectively.[22] To put these numbers into perspective, the Federal Reserve estimates that UMPs lowered a 10-year U.S. Treasury by 25 basis points. Moreover, they consider that a reduction of more than 25 basis points in the Federal Reserve's Fed Funds rate would have been required to achieve the same outcome (Fischer, 2016). The estimates thus provide an element of a broader assessment of the potential benefits and costs of implementing any policy aimed at reducing excess reserve accumulation.

## V. Conclusions

This paper has shown that the demand for high quality reserve assets (i.e. uphill capital flows) in the form of U.S. Treasuries reduces their yields. It suggests that uphill capital flows associated with the accumulation of international reserves across the world is a key transmission channel in the IMS. Indeed, not only do they affect domestic financing conditions, but quite importantly they also affect the transmission of monetary policy in the U.S., and global financing conditions. While lowering the U.S. Treasury yields may result in

[21] For a discussion on the role of the SDR see IMF (2016a,b) and Tovar (2017).

[22] This is lower than the estimate of 17-20 basis points by Beltran et al. (2013). One of the possible reasons is that foreign official holdings are expressed relative to total outstanding marketable debt in the estimated models, therefore the impact of a US$ 100 billion decrease in demand on yields depends on the stock of debt. As total outstanding debt has been continuously increasing, the impact

an advantage for the U.S. as a reserve issuer (the so-called *exorbitant privilege*), these flows also pose some major drawbacks for the U.S. as a reserve issuer. First, uphill capital flows can distort financing conditions and erode the incentives for adequate consumption and investment decisions, both in the private and public sector, thereby contributing to—stock and flow—external imbalances. Second, they can also undermine the independence and effectiveness of monetary policy in the U.S. by weakening the transmission of monetary policy across the yield curve. Finally, given the benchmark role of U.S. Treasuries, it can exacerbate the global economic and financial cycle, say, by influencing interest-rate arbitrage driven capital flows, risk-taking behavior, and global real interest rates.

From a policy perspective, our results suggest that a global policy aimed at reducing the demand for high quality assets associated with reserve accumulation would have non-negligible effects. However, two questions would remain: (i) to what extent would such policy help reduce spillovers to the rest of the world; and (ii) having measured the distortions on the IMS—i.e. the spillbacks and spillovers—what would be the most effective global policy instrument to achieve this outcome? These questions are left for further research.

## ANNEX 1. ANNOUNCEMENTS BY THE FEDERAL RESERVE

| Date | Program | Event | Description |
|---|---|---|---|
| 11/25/2008 | QE1 | Initial LSAP announcement | Federal Reserve announces purchases of up to $100 billion in agency debt and $500 billion in agency MBS. |
| 12/1/2008 | QE1 | Bernanke speech | Chairman Bernanke says that "the Fed could purchase *longer-term Treasury* or agency securities on the open market in substantial quantities". |
| 12/16/2008 | QE1 | FOMC statement | FOMC indicates that it stands ready to expand its purchases of agency debt and MBS as well as is evaluating the potential benefits of purchasing longer-term Treasury securities. |
| 1/28/2009 | QE1 | FOMC statement | FOMC reiterates that it stands ready to expand its purchases of agency debt and MBS, and is prepared to purchase longer-term Treasury securities. |
| 3/18/2009 | QE1 | FOMC statement | FOMC announces additional purchases of up to $100 billion in agency debt and up to $750 billion in agency MBS, as well as to buy up to $300 billion in longer-term Treasury securities over the next six months. |
| 8/10/2010 | QE1 | FOMC statement | FOMC will reinvest principal payments from agency debt, agency MBS and Treasury securities in longer-term Treasury securities. |
| 8/27/2010 | QE2 | Bernanke speech | Chairman Bernanke argues that "additional purchases of longer-term securities [...] would be effective in further easing financial conditions." |
| 9/21/2010 | | FOMC statement | FOMC will "maintain its existing policy of reinvesting principal payments from its securities holdings." |
| 10/15/2010 | QE2 | Bernanke speech | Chairman Bernanke says that "a means of providing additional monetary stimulus, if warranted, would be to expand the Federal Reserve's holdings of longer-term securities." |
| 11/3/2010 | QE2 | FOMC statement | FOMC announces the purchase of "a further $600 billion of longer-term Treasury securities by the end of the second quarter of 2011, a pace of about $75 billion per month." |
| 9/21/2011 | Operation Twist | FOMC statement | FOMC announces the purchase of $400 billion of Treasury securities with remaining maturities of 6 years to 30 years and to sell an equal amount of Treasury securities with remaining maturities of 3 years or less by the end of June 201. |

| ANNEX 1. ANNOUNCEMENTS BY THE FEDERAL RESERVE (CONTINUED) | | | |
|---|---|---|---|
| 6/20/2012 | Operation Twist | FOMC statement | FOMC announces to continue the maturity extension program through the end of 2012. |
| 8/22/2012 | QE3 | FOMC minutes | At the July 31-August 1 FOMC meeting, "many members judged that additional monetary accommodation would likely be warranted fairly soon." |
| 8/31/2012 | QE3 | Bernanke speech | Chairman Bernanke says that "the Federal Reserve will provide additional policy accommodation as needed to promote a stronger economic recovery and sustained improvement in labor market conditions in a context of price stability." |
| 9/13/2012 | QE3 | FOMC statement | FOMC announces the purchase of additional agency MBS at a pace of $40 billion per month. |
| 12/12/2012 | QE3 | FOMC statement | FOMC announces the purchase of longer-term Treasury securities, initially at a pace of $45 billion per month, as well as the continued purchase of agency MBS at a pace of $40 billion per month. |
| 5/22/2013 | Tapering | Bernanke testimony | Chairman Bernanke says that “If we see continued improvement and we have confidence that that is going to be sustained, then in the next few meetings, we could take a step down in our pace of purchases." |
| 6/19/2013 | Tapering | Bernanke speech | Chairman Bernanke says that "if the incoming data are broadly consistent with this forecast, the Committee currently anticipates that it would be appropriate to moderate the monthly pace of purchases later this year." |
| 12/18/2013 | Tapering | FOMC statement | FOMC announces to reduce the pace of asset purchases to $35 billion per month for agency MBS and to $40 billion per month for longer-term Treasury securities, beginning in January 2014. |
| 1/29/2014 | Tapering | FOMC statement | FOMC announces to reduce the pace of asset purchases to $30 billion per month for agency MBS and to $35 billion per month for longer-term Treasury securities, beginning in February 2014. |
| 3/19/2014 | Tapering | FOMC statement | FOMC announces to reduce the pace of asset purchases to $25 billion per month for agency MBS and to $30 billion per month for longer-term Treasury securities, beginning in April 2014. |
| 4/30/2014 | Tapering | FOMC statement | FOMC announces to reduce the pace of asset purchases to $20 billion per month for agency MBS and to $25 billion permonth for longer-term Treasury securities, beginning in May 2014. |

**ANNEX 1. ANNOUNCEMENTS BY THE FEDERAL RESERVE (CONCLUDED)**

| | | | |
|---|---|---|---|
| 6/18/2014 | Tapering | FOMC statement | FOMC announces to reduce the pace of asset purchases to $15 billion per month for agency MBS and to $20 billion per month for longer-term Treasury securities, beginning in July 2014. |
| 7/30/2014 | Tapering | FOMC statement | FOMC announces to reduce the pace of asset purchases to $10 billion per month for agency MBS and to $15 billion per month for longer-term Treasury securities, beginning in August 2014. |
| 9/17/2014 | Tapering | FOMC statement | FOMC announces to reduce the pace of asset purchases to $5 billion per month for agency MBS and to $10 billion per month for longer-term Treasury securities, beginning in October 2014. |
| 10/29/2014 | Tapering | FOMC statement | FOMC announces to conclude its asset purchase program. |

Source: Glick and Leduc (2013) and authors' own compilation.

## ANNEX 2. THEORETICAL FRAMEWORK

Formally, we can follow Wickens (2011) to show why the impact of foreign official holdings of securities on the yield curve can be studied by analyzing its relationship with the term premium.

Let the holding-period return be the nominal rate of return of holding a zero-coupon bond for one period.[1] Letting $h_{n,t+1}$ be the holding-period return on an n-period bond between periods t and t+1, then:

$$1 + h_{n,t+1} = \frac{P_{n-1,t+1}}{P_{n,t}} = \frac{\left(1 + R_{n-1,t+1}\right)^{-(n-1)}}{\left(1 + R_{n,t}\right)^{-n}}$$

where $P_{n,t}$ is the price of the zero-coupon bond with n-periods to maturity at time $t$ , and $R_{n,t}$the yield to maturity. Letting lower case variables denote logs prices and imposing the no-arbitrage condition for bonds—i.e. that after adjusting for risk, investors are indifferent between holding an n-period bond and a risk-free bond for one period—then we can show that:

$$E_t h_{n,t+1} = (n-1)\left(E_t R_{n-1,t+1} - R_{n,t}\right) = \left(R_{n,t} - s_t\right) - \rho_{n,t}$$

where $\rho_{n,t}$ is the risk premium on an n-period bond at time t, $s_t = r_t^f = R_{1,t} = -lnP_{1,t}$, and $R_{n,t} - s_t$ is the term spread.[2] $E_t$ is the expectations operator. Now, using forward substitution, it is possible to show that:

$$R_{n,t} = \frac{1}{n}\sum_{i=0}^{n-1} E_t\left(s_{t+i} + \rho_{n-i,t+i}\right)$$

That is, the nominal yield to maturity is the average of expected future rates plus the average risk premium on the bond over the rest of the life.

Since the Fisher equation defines a one-period real interest rate $r_t$ by:

$$r_t = s_t - E_t\pi_{t+1}$$

where $\pi_t$ denotes the inflation rate at t, then we can show that:

$$R_{n,t} = \frac{1}{n}\sum_{i=0}^{n-1} E_t\left(r_{t+i} + E_t\pi_{t+1} + \rho_{n-i,t+i}\right)$$

[1] Without loss of generality, we work with a zero coupon bond, as the n-period coupon bond can be thought as a collection of pure discount bonds with payoff in period to $t$ to $t + n - 1$.

[2] Equation (1) is the rational-expectations hypothesis of the terms structure when the risk premium (i.e. the term premium) is omitted.

Long-term interest rates can therefore be decomposed into three components: expectations about the future path of short-term real interest rates, expected inflation, and the term premium.

The presence of the term premium is relevant because it allows supply and demand conditions pertaining specifically to bonds of that maturity to affect pricing.[3] To the extent that foreign official holdings of U.S. securities do not affect the path of real interest rate and/or expected inflation, their impact on the shape of the yield curve will only operate through the risk or term premium. In other words, this implies that the impact of foreign official purchases of U.S. Treasuries on the U.S. yield curve can be reduced to an analysis of its relationship with the term premium.[4]

A key issue then is how to specify the term premium. The standard approach in finance is to rely on affine factor models of the term structure. Based on certain assumptions about how latent factors behave, this approach extracts measures of the term premium directly from the yield curve. This may be contrasted with the general equilibrium approach to asset pricing where the factors are observable macroeconomic variables (*Rudebush et al.*, 2006). More recently, both approaches have been combined through the use of latent and observable variables.

[3] The presence of idiosyncratic effects associated with a certain maturity of bonds is sometimes linked to the preferred habitat theory, that is, that certain investors have a preference for purchasing assets of specific maturities.

[4] Foreign official holdings could affect the future path of short-term interest rates if foreign exchange interventions by foreign central banks have an impact on growth and inflation outlook in the United States. For example, interventions aimed at keeping the currency undervalued relative to the U.S. dollar could lower economic growth and inflation in the United States by hurting its competitiveness, thereby triggering looser monetary conditions and lower short-term interest rates. For the purposes of this study we assume that this channel is of second order.

## ANNEX 3. COINTEGRATION TESTS

**Annex Table 1. Lag Selection and Cointegration Tests**

| | 2-year | | 3-year | | 5-year | | 7-year | | 10-year | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Lag Selection** | | | | | | | | | |
| | HQIC | AIC | HQIC | AIC | HQIC | AIC | HQIC | AIC | HQIC | AIC |
| Optimal Lag | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 1 lag | 8.42 | 8.61 | 8.93 | 9.13 | 9.59 | 9.79 | 9.94 | 10.14 | 10.25 | 10.45 |
| 2 lags | 7.90 | 8.29 | 8.41 | 8.80 | 9.04 | 9.43 | 9.37 | 9.77 | 9.67 | 10.06 |
| 3 lags | 7.95 | 8.53 | 8.46 | 9.05 | 9.10 | 9.68 | 9.41 | 10.00 | 9.69 | 10.27 |
| | **Cointegration Tests (2 lags)** | | | | | | | | | |
| Rank | 1 | | 1 | | 1 | | 1 | | 1 | |
| *Maximum Eigenvalue Test* | | | | | | | | | | |
| None | 35.8* | | 32.9* | | 28.0* | | 26.5* | | 25.9* | |
| At most 1 | 11.7 | | 11.8 | | 11.9 | | 11.9 | | 11.9 | |
| At most 2 | 3.4 | | 4.0 | | 4.4 | | 4.4 | | 4.2 | |
| *Trace Test* | | | | | | | | | | |
| None | 51.1* | | 48.8* | | 44.5* | | 43.0* | | 42.1* | |
| At most 1 | 15.2 | | 15.9 | | 16.4 | | 16.4 | | 16.2 | |
| At most 2 | 3.5 | | 4.1 | | 4.5 | | 4.5 | | 4.3 | |

Note: * indicates rejection of the null hypothesis.

## REFERENCES


Adrian, T., 2013, "Treasury market liquidity: an overview", Presentation at the 3rd U.S. Treasury Roundtable on Treasury Markets and Debt Management & 13th International Monetary Fund Public Debt Management Forum, June 19–20. Federal Reserve Bank of New York.

_____, R.K. Crump, and E. Moench, 2013, "Pricing the Term Structure with Linear Regressions", Journal of Financial Economics 110, no. 1 (October 2013): 110–38.

_____, R.K. Crump, B. Mills, and E. Moench, 2014, "Treasury Term Premia: 1961-Present", Liberty Street Economics, May 12, 2014.

Bank for International Settlements, 2016, *Triennial Central Bank Survey of Foreign Exchange and OTC Derivatives Markets*, November.

Beltran, D.O., M. Kretchmer, J. Marquez, and C.P. Thomas, 2013, "Foreign Holdings of U.S. Treasuries and U.S. Treasury Yields", Journal of International Money and Finance, Vol. 32, pp. 1120–1143.

Bernanke, B.S., 2015a, "Federal Reserve Policy in an International Context", Paper presented at the 16th Jacques Polak Annual Research Conference, International Monetary Fund, November.

———, 2015b, "Why are interest rates so low, part 4: Term premiums", Brookings Blogs, April 13, 2015.

———, 2005, "The Global Saving Glut and the U.S. Current Account Deficit," Homer Jones Lecture, Federal Reserve Bank of St. Louis, St. Louis, Missouri, April 14, 2005.

———, Carol Bertaut, Laurie Pounder, and Steven Kamin, 2011a, "International Capital flows and returns to safe assets in the United States, 2003-2007", International Fiance Discussion Papers, number 1014. February.

———, 2011b, "Testimony: Semiannual Monetary Policy Report to the Congress", Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, Washington, D.C., March 1.

———,, V. Reinhart, and B. Sack, 2004, "Monetary policy alternatives at the zero bound: An empirical assessment", Brookings Papers on Economic Activity, 35(2): 1–100.

Bertaut, C.C., and R. Judson, 2014, "Estimating U.S. Cross-Border Securities Positions: New Data and New Methods", International Finance Discussion Papers No. 1113, Board of Governors of the Federal Reserve System.

———, and R.W. Tryon, 2007, "Monthly Estimates of U.S. Cross-Border Securities Positions", International Finance Discussion Papers No. 910, Board of Governors of the Federal Reserve System.

Borio, C., 2016 “More pluralism, more stability?”, Presentation at the Seventh High-Level SNB-IMF Conference on the International Monetary System, Zurich, May.

———, 2014, “The international monetary system: its Achilles heel and what to do about it?, BIS Working Papers No. 456, August.

Boz, E., L. Cubeddu, and M. Obstfeld, 2017, “Revisiting the Paradox of Capital: The Reversal of Uphill Flows”, IMFBlog, March 7, 2017

Chinn, M. and K. Kucko, 2015, “The predictive power of the yield curve across countries and time”, International Finance, pp. 1–28.

Chutasripanich, N., and J. Yetman, 2015, “Foreign exchange intervention: strategies and effectiveness”, BIS Working Papers No 499.

D’Amico, K., and T.B. King, 2010, “Flow and Stock Effects of Large-Scale Treasury Purchases”, Finance and Economics Discussion Series 2010-52, Federal Reserve Board.

———, S., W. English, D. Lopez-Salido, and E. Nelson, 2012, “The Federal Reserve’s Large-Scale Asset Purchase Programs: Rationale and Effects”, Finance and Economics Discussion Series 2012-85, Federal Reserve Board.

Eichengreen, B., 2011, *Exorbitant Privileged—The Rise and Fall of the Dollar and the Future of the International Monetary System,* Oxford University Press.

Farhi, E., P.O. Gourinchas, H. Rey, 2011, *Reforming the International Monetary System*, Center for Economic Policy Research.

Fischer, S, 2016, “U.S. Monetary Policy from an International Perspective” Speech given at the 20th Annual Conference of the Central Bank of Chile, November, Santiago.

Gagnon, J., M. Raskin, J. Remache, and B. Sack, 2011, “Large-Scale Asset Purchases by the Federal Reserve: Did They Work?”, FRBNY Economic Policy Review, May 2011.

Gerlach-Kristen, P., R. McCauley, and K. Ueda, 2012, “Currency intervention and the global portfolio balance effect: Japanese lessons”, BIS Working Paper, 389.

Glick, R., and S. Leduc, 2012, “Central bank announcements of asset purchases and the impact on global financial and commodity markets”, Journal of International Money and Finance Vol. 31, pp. 2078–2101.

Gourinchas, P.O., and O. Jeanne, 2007, “Capital Flows to Developing Countries: The Allocation Puzzle”, NBER Working Paper 13602.

Greenspan, A., 2005, “Testimony of Chairman Alan Greenspan”, Federal Reserve Board's semiannual Monetary Policy Report to the Congress Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, February 16, 2005.

Gurkaynak, R.S., B. Sack, and J.H. Wright, 2006, "The U.S. Treasury Yield Curve: 1961 to the Present", Finance and Economic Discussion Series No. 28, Board of Governors of the Federal Reserve System.

International Monetary Fund, 2016a, "Strengthening the International Monetary System—Stocktaking", Washington D.C. March.

———, 2016b, "Staff note for the G20: The Role of the SDR—Initial Considerations," Washington D.C..

———, 2013, "Unconventional Monetary Policies—Recent Experience and Prospects", Washington D.C.

———, 2011a, "Assessing Reserve Adequacy", Washington D.C.

———, 2011b, "Strengthening the International Monetary System: Taking Stock and Looking Ahead", Washington D.C. March.

———, 2011c, "Enhancing International Monetary Stability—A role for the SDR", Washington D.C. January.

Kaminska, I., and G. Zinna, 2014, "Official Demand for U.S. Debt: Implications for U.S. Real Interest Rates", IMF Working Paper 14/66.

Katzenstein, S., 2015, "Dollar unilateralism; The new frontline of national security," Indiana Law Journal, Vol. 90, Issue 1, Article 8.

Kitchen, J., and M. Chinn, 2011, "Financing US Debt: Is There Enough Money in the World – and at What Cost?", International Finance 14:3, pp. 373–413.

Lucas, R.E., 1990, "Why Doesn't Capital Flow from Rich to Poor Countries?", The American Economic Review Vol. 80, No. 2, pp. 92–96.

Malhar, N, and C.E. Tovar, 2017, "Renminbi Internationalization", in R. Lam, M. Rodlauer, and A. Shipke (Eds.) *Modernizing China: Investing in Soft Infrastructure*, International Monetary Fund, Washington D.C.

McCauley, R., and G. Jiang, 2004, "Treasury yields and foreign official holdings of US bonds", BIS Quarterly Review, March 2014, pp. 11–12.

McGuire Patrick and Goetz von Peter, 2009, "The U.S. Dollar shortage in banking," BIS Quarterly Review, March.

Mohanty, M.S., and P. Turner, 2006, "Foreign exchange reserve accumulation in emerging markets: what are the domestic implications?", BIS Quarterly Review, September 2006.

Paruolo, P., 1997, "Asymptotic Inference on the Moving Average Impact Matrix in Cointegrated I(1) VAR Systems", Econometric Theory, Vol. 13, pp. 79–118.

Piazzesi, M., 2010, "Affine term structure models" in *Handbook of Financial Econometrics* Aït-Sahalia and Hansen (Eds.), North Holland.

Prasad, Eswar, 2014, *The Dollar Trap—How the U.S. Dollar Tightened its Grip on Global Finance*, Princeton University Press.

Rudebusch, G.D., E.T. Swanson, and T. Wu, 2006, "The Bond Yield "Conundrum" from a Macro-Finance Perspective", Federal Reserve Bank of San Francisco Working Paper 2006-16.

Sierra, J., 2010, "International Capital Flows and Bond Risk Premia", Bank of Canada Working Paper 2010-14.

Stein, J.C., 2012, "Evaluating Large-Scale Asset Purchases", Speech at the Brookings Institution, October 11, 2012.

Tovar, C.E., 2017, "The Sleeping Beauty? Risk-Return Characteristics of SDR-Denominated Securities," IMF Working Paper, forthcoming.

——— and T. Mohd Nor, 2017, "Currency Blocs: A Changing International Monetary System?", IMF Working Paper, forthcoming.

Warnock, F.E., and V.C. Warnock, 2005, "International Capital Flows and U.S. Interest Rates", International Finance Discussion Papers No. 840, Board of Governors of the Federal Reserve System.

Wickens, M., 2011, Macroeconomic Theory: A Dynamic General Equilibrium Approach, 2nd Edition, Princeton University Press.

Wolcott, E.L., 2016, "Impact of Foreign Official Purchases of U.S. Treasuries on the Yield Curve", University of California, San Diego.

Wu, T., 2014, "Unconventional Monetary Policy and Long-Term Interest Rates", IMF Working Paper 14/189.

Wu, J.C., and F.D. Xia, 2014, "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound", Journal of Money, Credit and Banking , Vol. 48:2-3, pp. 253–291.

Zhou, X., 2009, "Reform the International Monetary System,", BIS Review 41.